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This bulletin appraises some of the major technological changes emerging among American industries, and it projects the impact of these changes over the next 5 to 10 years on patterns of employment, occupations, and issues requiring labor-management adjustment. The bulletin extends and updates the report, "Technological Trends in 36 Major American Industries," which was issued in 1964 for the President's Advisory Committee on Labor-Management Policy. Major industries are covered in 40 separate reports in the bulletin, some covering groups of related industries, and the emphasis in each report is on the outlook for technological changes. Statistical data pertaining to productivity, production, employment trends, investment, and research development, all of which provide a quantitative basis for assessing the implications of technological change, are shown in charts and tables and are analyzed in the text. Among the implications were: (1) All industries will be affected, to some degree, by changes in equipment, methods of production, materials, and products, (2) Employment prospects in the industries studied are generally favorable, and (3) Prospective technological changes will continue to reduce the proportion of jobs involving primarily physical and manual ability and to increase the need for jobs requiring ability to work with data and information. (ET)

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TECHNOLOGICAL TRENDS IN MAJOR AMERICAN INDUSTRIES

Bulletin No. 1474

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UNITED STATES DEPARTMENT OF LABOR
W. Willard Wirtz, Secretary
BUREAU OF LABOR STATISTICS
Arthur M. Ross, Commissioner

TECHNOLOGICAL TRENDS IN MAJOR AMERICAN INDUSTRIES

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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February 1966

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Preface

This bulletin appraises some of the major technological changes emerging among American industries and projects the impact of these changes over the next 5 to 10 years.

The Manpower Development and Training Act of 1962 requires the Secretary of Labor to "evaluate the impact of and benefits and problems created by automation, technological progress and other changes in the structure of production and demand on the use of the Nation's human resources; establish techniques and methods for detecting in advance the potential impact of such developments; . . ."

This publication helps meet that requirement by evaluating the general effects that current and probable future technological developments will have on patterns of employment, occupations, and issues requiring labor-management adjustment. It extends and updates the report, *Technological Trends in 36 Major American Industries*, which was issued in 1964 for the President's Advisory Committee on Labor-Management Policy.

The bulletin was prepared in the Division of Technological Studies, under the direction of Edgar Weinberg, Chief, as part of the Bureau's research program on productivity and technological developments under the general direction of Leon Greenberg, Assistant Commissioner. The reports on individual industries were written under the direct supervision of John Macut, Chief, Branch of Innovation Studies and John Shott, Chief, Branch of Industry Outlook Studies. Staff members who prepared studies of various industries were: Robert Adams, Robert Ball, Robert Barry, Gordon Chapman, Audrey Freedman, Arthur Herman, Richard Johnson, Stephen Keyes, Richard Lyon, Richard Riche, and Rose Zeisel. Susan Casher and Mable Elliott assisted in the preparation.

Also utilized in the preparation of this report was manpower research conducted as part of other Bureau of Labor Statistics' programs, especially in the Division of Manpower and Occupational Outlook, Sol Swerdloff, Chief, and in the Division of Economic Growth, Jack Alterman, Director.

Preparation of this bulletin could not have been accomplished without the assistance of hundreds of experts in companies, government agencies, trade associations, trade journals, unions, and universities, who patiently and carefully answered queries and reviewed preliminary drafts. The Bureau of Labor Statistics is deeply grateful for their cooperation and aid.

Credits for published photographs are listed below: American Cement Co., American Gas Association, American Machine and Foundry Co., American Telephone and Telegraph Co., American Trucking Association, Atomic Energy Commission, Atomics International, Bucyrus-Erie Co., Cincinnati Milling and Grinding Machines, Inc., Crompton and Knowles Corp. and Leesona Corp., Firestone Tire and Rubber Co., General Motors Corp., Great Lakes Steel Corp., Greenlee Brothers and Co., Guntert and Zimmerman Construction Division, Inc., Honeywell, Inc., Illinois Central Railroad, International Paper Co., International Typographical Union, Kaiser Industries, Metropolitan Life Insurance Co., Monsanto Chemical Co., National Forest Products Association, Phoenix Cement Co., Port of New York Authority, Shaake Packing Co., Inc., The Sheffield Corp., The Southern Railway System, Unit Rig and Equipment Co., and Willcox and Gibbs Sewing Machine Co.

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Technological Trends in Major American Industries

PART I. INTRODUCTION

This bulletin provides information about significant developments in technology in major American industries.

Historically, the introduction and use of new products, machines, methods, and materials have resulted in economic and social gains, but such technological innovation also has affected employment levels, and skills and job security of employees. Advance knowledge and understanding of impending technological change could help companies, unions, and government to formulate in advance appropriate retraining and readjustment policies to minimize its disrupting effects on individual workers.

The basic definitions and concepts of technological change and its relation to productivity and employment are presented in the introduction. Part II summarizes broad technological developments and their implications. Part III presents the methods of analysis, the limitations of the study, and sources of information. Part IV comprises the 40 reports on major industries. Part V presents a bibliography on technological change, and manpower trends and adjustments.

Meaning of Technological Change

In this study, the term "technological change" means the introduction of new arrangements in the process of production and distribution which make possible new or improved products or services. The basic characteristic of technological change is that it permits resources to be utilized more efficiently. For a given amount of output, less capital, labor, and material inputs may be required; or the same amount of resources may allow greater output to be produced.

The introduction of new machines, processes, or products also can be considered as a step in a sequence that extends over a fairly long period. The accumulation of knowledge, underlying technological progress, represents the work of many scientists, inventors, and engineers. Inventions are developed, tested, and evaluated by industry before they are put on the market. The adoption period is the most significant period in terms of economic impact.

Industry's acceptance of an innovation is neither automatic nor immediate. Expected savings over existing technology must be large enough to induce the first users to invest in the new equipment. Once profitability of the new process or product is proven, acceptance by the bulk of the industry accelerates. In practice, adoption of an innovation in an industry depends on many nontechnical factors, investment decisions by individual firms being influenced by market prospects, competitive conditions, capital requirements, character of management, union attitude, government codes and regulations, and other factors. Thus, the pace of technological change is closely related to the rate of gross investment, the level of economic activity, and the changing structure of production and demand.

Technological Change, Productivity, and Employment

The rate of technological advance (including small as well as major improvements in machinery and managerial arrangements) generally is measured in terms of productivity, customarily output per man-hour. Increased output from given inputs means rising productivity. While technological change is the most important factor in the growth of productivity, it is not the sole factor. The trend of productivity is also influenced by nontechnical factors, such as rate of capacity utilization and long-term improvements in skill and education level of the work force, and in the ability and knowledge of management.

Gains as well as losses in employment may result from the introduction of machinery even if the direct effect on a specific operation is labor saving. The innovation may reduce total unit cost to such an extent that sales increase more sharply than the reduction in unit labor requirements or may permit work to be done that hitherto was uneconomic. In these cases, additional employees are required.

Job losses may result in other instances because of inability to expand sales sufficiently. Changes in consumer's technology or inroads of competitive materials or products may result in lower sales and add to the number of workers displaced. In some cases, the total number of jobs may be reduced but the company may retrain and reassign workers to other vacancies. Under competitive conditions, firms that make cost-cutting changes may expand their share of the market but at the expense of higher cost plants which may be forced to close.

In all cases, expanding levels of economic activity facilitate overall adjustment to lowered manpower requirements in a plant or industry, since displaced workers are better able to find new employment in other expanding plants. On the other hand, declining business activity increases the difficulties of adjustment because fewer employment opportunities are available to displaced workers.

Over the longrun and for the entire economy, output generally has increased with advancing productivity. New products, processes, and equipment have contributed to expansion of investment, consumption, and job opportunities by making cost reductions possible; living standards have risen along with greater leisure for the average worker. Over short periods, however, employment opportunities have not always expanded sufficiently to match the growth in number of people seeking work, including those workers displaced by laborsaving technology. Unemployment resulting from such maladjustment is particularly aggravated when technological change leads to higher skill requirements and many of those who are unemployed lack education and training. Expansion of total output and retraining are therefore keys to the solution of unemployment problems.

Technological Development in Perspective

Three stages of development characterize the continuing industrial revolution: The *Age of Mechanization* began with the introduction of power-driven machinery, the displacement of the handicraft worker, and the rise of the factory system. In the *Age of Mass Production*, the factory worker's job became a faster operation; mechanical conveyors carried a highly standardized product to the work place; power production was transferred from steam-driven shaft and belt systems for each factory to central electric power generating stations.

A third phase, an *Age of Science and Technology*, which began after World War II, emphasizes research and development by the Federal Government and private corporations. This research already has resulted in such unforeseen developments as electronic computers, nuclear energy, jet propulsion, space technology, and automation of industrial processes. Continued rapid growth of population (and markets), increasing foreign competition, and pressure for higher living standards are stimulating ever greater efforts to increase output at lower cost by improving technology.

Popularly, the term "automation" is applied to all types of technological change that economize on the use of labor. The technical meaning includes automatic controls, electronic computers, highly automatic transfer machines, and new methods of managerial organization. Automation removes the worker from the direct, step-by-step control of operations and increases the importance of technical planners, programers, and engineers.

The future probably will be characterized by a continuing emphasis on social innovations to cope with problems raised by advances in technology. Such innovations include improvements in the education and training of young people, measures for retraining and increasing the mobility of the labor force, and more adequate provisions for maintenance of income of unemployed workers. The Employment Act of 1946 gives explicit consideration to measures to achieve and maintain a high level of employment. A third field of social invention involves labor and management in the creation of new collective bargaining approaches to deal with problems of technological change. These and other measures will constitute the social framework for future technological advances.

PART II. SUMMARY AND IMPLICATIONS

Part II describes trends in nine broad areas of technological innovation and discusses briefly some implications. Although each of these areas is considered separately, specific changes in any one of the broad groupings are often related to changes in others. Advances in transportation, for example, involve electronic data processing, instrumentation, communication systems, and new materials handling concepts. The overall contribution of each broad development cannot be measured precisely; but some examples from specific industries, described in Part IV, are presented.

Summary of Major Trends

Computerization of Data Processing. The introduction and development of the electronic computer have resulted in far-reaching technological applications not generally anticipated when the computer was invented 20 years ago. The computer's enormous capabilities are measured by the amount of information it can store, the number of basic instructions it can perform per second, and the reliability of its operation. Because data-processing operations are found in a wide range of scientific, business, and industrial activities, the potential for productivity gains could be significant.

The electronic computer was first used commercially for data processing in 1951. By mid-1965, the total number of digital computer systems installed, according to one unofficial estimate, was about 25,000. Additional thousands are on order. The manufacture of electronic data-processing equipment has become a billion dollar industry, the value of shipments in 1964 reaching about three times the 1959 value.

Electronic computers are being used in all branches of industry, business, and government. Six industrial sectors have the bulk of the installations: Federal Government, insurance, banks, and aerospace, electrical machinery, and automobile industries. Most of the large corporations in the United States have computers, and smaller businesses, for whom an installation may be uneconomical, have access to the use of computers at numerous service centers.

The technical possibilities of computers are being extended constantly. The potential speed and storage capacity of the latest computer models are several hundred times faster than earlier models. "Third generation" computers, now available in various capacity models, utilize faster microcircuits instead of transistors. Major advances in auxiliary equipment, such as data communication systems, optical character recognition machines, and high-speed printers will make it possible to realize more fully the potentialities of high-speed electronic data processing.

Timesharing of computer programing—a technique now being tested—would permit different users in different locations to use the same computer at the same time. The different users communicate with a computer at the same time, as in a telephone system. Timesharing is particularly important in many scientific research and engineering applications where the need for rapid calculation is critical but intermittent.

The ultimate impact of computers is open to much speculation. The most extensive uses, so far, are in large-scale routine data processing operations such as accounting, billing, inventory control, production planning and control, and in scientific and engineering applications. Electronic data processing also is being extended gradually, where economically feasible, to operations connected more directly with production.

Computers are used, for example, in the *printing industry*, to speed preparation of control tapes which guide typesetting machines; in *crude petroleum and natural gas*, to store and retrieve information; in the *automobile industry*, to design and draft new car models; on *railroads*, to keep account of the location of freight cars; and by *airlines*, for intercompany control of seat inventory; in *oil exploration* and in *construction*, to schedule operations. Computers are also used in process control industries and with numerical control of machine tools—applications which are discussed in sections below.

Greater Instrumentation and Process Control. More precise and varied instrumentation extends human sensory capabilities and opens new possibilities for scientific advance and industrial automatization. Complex and novel instruments are necessary for launching and tracking satellites, for operating oceanographic laboratories, and for constructing multimillion dollar electron accelerators.

Advances in scientific instrumentation result in improved industrial technology. New and unusually sensitive devices, developed in laboratories for measuring and controlling very high temperature, vacuum or radiation, are making possible extra high purification of metals, freeze drying of foods, testing of space vehicles and other new industrial processes. Examples of new or increasing industrial applications of instruments are X-rays and radioisotopes for inspecting castings in *foundries,* electronic devices for counting seeds and determining flour particle size in *flour milling,* instruments for detecting potential engine breakdowns in *motor freight* and electronic inspecting devices to check quality and weight in *cigarette manufacture.*

In process industries, instruments and integrated systems of control devices to regulate automatically chemical and physical changes in liquids and gases are becoming a basic part of plant design. Processing variables such as level, flow, temperature, or pressure are measured continuously and recorded, and held at desired values by servomechanisms which open and close valves and operate pumps under rigidly controlled conditions. Centralization of all instrument readings and controls in one control panel achieves significant laborsavings.

Applications of centralized control instrumentation are found in systems for regulating pumps, tanks, and gathering lines in the *crude petroleum and natural gas industry;* systems of microphones, closed-circuit TV and X-ray spectrometers in *cement* production; and X-ray analysis and instrumentation for quality control of the concentrator in *copper mining.*

As more quantitative knowledge is acquired about the nature of various chemical processes, and instruments are improved, process industries are expected to use computers increasingly for control. Complex computations based on vast quantities of data from instruments can be made rapidly and accurately on computers and the results fed back to the operator who sets the controls. A more advanced type of computer process control known as closed-loop control bypasses the operator and sets the controls automatically. Improved quality and greater reliability, as well as savings in labor and capital per unit of output are said to be possible.

According to a McGraw-Hill annual survey, about 400 process computers, by early 1965, had been installed in process industries, chiefly, *petroleum refining; paper manufacturing; textiles; steel mill finishing operations; chemical, cement, and electric power plants; and oil pipelines.* Substantial growth is anticipated with estimates for 1970 ranging from 1,500 to 4,000 installations. Less than a dozen closed-loop control systems are being tested or are in operation. Technical complexities, lack of engineering skills and cost are some obstacles to more rapid growth.

Trend Toward Increased Mechanization. Improvements in machinery that do not involve drastic departure from conventional design will continue to be an important factor in raising productivity in many industries. Faster operation, larger size, automatic loading and unloading devices, and automatic lubrication significantly reduce the amount of labor required per unit of output. The integration of a number of separate operations into one large specialized machine which performs a long cycle of operations with a minimum of intervention by the machine tender constitutes a more advanced type of mechanization.

Examples of greater mechanization are found in many industries: faster *textile* machine speeds with larger packages of stock; continuous *steel* casting machines that require one-half the number of steps in conventional ingot casting; machinery in *meatpacking* for continuous production of frankfurters; tape controlled line casting machines in *printing;* faster, larger capacity machines in *tire and tube* manufacture; *railroad* track maintenance equipment that takes the place of two or more machines and larger crews; and slip-form pavers combining several operations that reduce the number of laborers employed in *highway construction.*

Other examples are mechanical "lumberjacks" to cut trees in the *lumber industry;* larger capacity stripping equipment in *copper mining;* greater use of larger continuous *coal mining* machines; and a machine that combines a number of operations in shirtmaking.

As fabricating operations become highly mechanized, new ways are sought to achieve laborsavings in moving goods and materials from one plant operation to the next. Mechanized materials handling often is introduced or improved to utilize more fully the high speed and large capacity of modernized fabricating equipment. Sales of materials-handling equipment (conveyors, cranes, hoists, industrial trucks, and elevators) are expected to amount to about $2 billion in 1965.

Among the important improvements and innovations in materials handling are more powerful, faster and more maneuverable models of forklift trucks, hoists, cranes (including tower cranes) and larger earthmoving equipment in *construction,* pneumatic conveyors for moving granular materials in *bakeries,* and a combination of unmanned trucks with remote computer control by large *wholesalers, retail department and chain stores, and air freight terminals.*

Progress in Communication. A broad range of advances in communication probably will be among the important factors in the growth of the economy over the next 5 to 10 years. Data transmission, via telephone, is expected to become an important adjunct of electronic data processing. Fast copying machines, color television, color printing, video tape recorders, polaroid color cameras, teaching machines, and new devices for speeding the mail are some of the innovations that are creating opportunities for new investment and employment growth.

More spectacular are the prospects of high quality international communications via communication satellites. Rapid growth of overseas telephone service contributes to and results from a large-scale expansion of international business operations. The global extension of communications builds on an evergrowing domestic telecommunications system of increasing complexity, automaticity, and diversity of services.

Business organizations are installing new communication techniques to speed transmission of information, facilitate remote control of hazardous work processes and increase reliability of operations. The *railroads,* for example, are increasing their use of microwave, closed-circuit television and two-way radio; the possibility of connecting the push-button telephone to a computer at *banks* to permit payment of bills is being tested; closed-circuit TV systems are used to monitor *paper and pulp* operations from remote stations; and multistore organizations are linked to a central computer, to facilitate more efficient managerial control in *wholesaling and retailing.*

Advances in Metalworking Operations. Advances in metalworking technology have far-reaching implications, not only because metalworking industries comprise a large sector of manufacturing, but because cost savings in producing industrial machinery stimulate mechanization. Cheaper machinery could ultimately mean a faster pace of technological change in many sectors of the economy.

Metalcutting and metal-forming tools are being improved constantly. Increased power, faster loading and unloading, and greater precision, flexibility, and versatility raise productivity of machine tools. Possibly of greater significance in the long run are new concepts in metalworking—numerical control, electrochemical, and electrical discharge machining—which have been developed largely as a result of the influence of the aerospace and electronics industries.

Numerical control is a technique for automatic operation of machine tools. Numerically coded instructions are recorded in advance on punched cards or magnetic tape and are interpreted by an electronic device to guide the tool. In some complicated applications, computers are used to prepare tapes.

First used commercially in 1957, numerical control is still in an early stage of application. About 7,000 numerically controlled machine tools were estimated to have been installed by fall 1965, constituting only a small fraction of the about 2 million machine tools in place. The *aircraft and missiles, motor vehicles, and machinery* industries are the principal users, but almost every metalworking industry has a few installations.

A fairly rapid growth is expected over the next 5 to 10 years as the advantages of numerical control are better understood and as programing is simplified. The laborsavings per unit of output in machining operations could be substantial. Important advantages are its great accuracy and its flexibility and applicability to small orders which form a large proportion of total machine shop work. The *motor vehicle industry,* for example, is expected to make increasing use of numerical control to fabricate tools and dies for its mass production machines.

Electrochemical and electrical discharge machining utilize electronic techniques to remove or shape metal parts. These techniques are particularly suited for machining hard alloy metals used in aircraft and motor vehicle production where conventional techniques are extremely expensive.

Developments in Energy and Power. New sources of energy, more efficient generation, and new ways of transporting energy are being developed to meet the ever increasing requirements of modern industry and urbanized society.

The search for new sources and methods of producing energy is continuing in many directions. More oil will be sought from newly explored offshore sources; but no less important is secondary recovery in older fields. The possible development of oil shale deposits would increase known reserves manyfold and would create a new industry in some western States. After nearly two decades of development, a few nuclear power plants are in operation and others are planned; but only a very small fraction of total electric power is expected to come from nuclear plants over the next decade. Unconventional methods—e.g., fuel cells which would dispense with conventional generators—are aso being investigated as possible supplements to existing methods.

Some technological developments continue to result in reductions in requirements of labor, capital, and raw materials per unit of output. In *petroleum refining,* for example, processing innovations result in greater yields from crude oil. The trend toward coordination and interchange of *electric power* on a regional basis is expected to reduce substantially plant capacity requirements.

The development of the "unitized train"—a specialized, low-cost fast service between coal mine and utility—is of great importance in maintaining coal's position as the principal source of fuel for electric power generation. However, this growing low-cost form of transportation may face competition from "coal by wire"—i.e., the extra high voltage transmission of large quantities of power over fairly long distances—in some cases from generating plants located at the mine head.

Advances in Transportation. A variety of innovations in all modes of transportation will continue to improve productivity in transportation industries over the next 5 to 10 years.

More powerful diesel-electric railroad locomotives can haul longer trains at higher speeds and with greater loads. Electronic control systems in classification yards and centralized traffic control also increase speed of rail traffic. Piggy-back service, which combines the hauling capacity of railroads with the flexibility of trucks, is expanding rapidly.

By 1970, practically all aircraft of scheduled airlines will be medium- and large-size jets. As faster aircraft are introduced, new, more reliable air traffic control systems are being installed and ground activities, including ticketing and baggage handling, are being speeded. Three new types of aircraft (supersonic, subsonic, and jet convertible) are under development.

Motor trucks equipped with more powerful engines, and constructed of light weight metals will probably increase capacity of equipment within legal weight limitations. In addition, highway improvements may permit larger and heavier trucks and higher average speeds.

In water transportation, pressure for technological improvements results primarily from a need to reduce costs to meet foreign competition. Faster ships with more automatic controls and significant changes in ship design to reduce labor requirements in cargo handling are being built. Hydrofoils and ground effect machines will be in limited use for intraurban travel by 1970. A few all-container ships now in service drastically reduce loading and unloading time.

New Materials, Products, and Processes. The development of new products and materials continues to be important sources of technological change and economic growth. Research and development (R&D) is directed, to a great extent, toward the creation of new products. New products also involve the development of new methods and types of equipment.

The increasing utilization of a wide range of synthetic materials is one of the most pervasive developments. Through "molecular engineering," chemists are developing ways of modifying plastic materials to obtain specified properties. Synthetic materials are uniform in quality and often require less labor because certain preparatory steps are not needed. Plastics are increasingy substituted for other materials in *construction, footwear, furniture, tires and tires, motor vehicles,* and such substitutions have had a major impact on the *textile industry.*

Technological innovations in food processing increasingly are concerned with making food more resistant to spoilage. These changes could have important effects on food distribution methods. For example, freeze drying and irradiation make possible meat storage for longer periods; sterilization of milk increases shelflife to 6 months; and freezing of bakery products allows regular baking schedules (thereby regularizing hours of bakery employees), more varied output and less frequent delivery by suppliers. In the malt liquor industry, the beer concentration process, if adopted, would facilitate bulk shipment with less transportation labor.

Managerial and Related Techniques. Besides the "hardware" of technology, new techniques of scientific management are likely to be sources of greater productivity. Scientific management was originated over 60 years ago in efforts to improve productivity by studying the individual worker performing a single task. Over the years, the scope of scientific management has been steadily extended to include questions of a broader nature. Since World War II, the emphasis has been on management's decisionmaking function and on mathematical techniques for handling quantitative information about business operations.

New tools include operations research, mathematical programing, critical path methods, and program evaluation and review technique (PERT). These systematic techniques of analyzing and controlling large complex projects have been applied in the *construction, instrument, aircraft, and electrical machinery industries.* They are applicable to major areas of management, including finance, production, and marketing. In the future, the computer may facilitate wider application of mathematical techniques to the solution of business problems.

Some Implications of Technological Change

Prospective technological developments suggest a number of implications for manpower trends and adjustments.

1. *All industries will be affected, to some degree, by prospective changes in equipment, methods of production, materials, and products.* Industries where extensive change will occur include steel, textiles, electric machinery, synthetic materials, aluminum, telephone, water transportation, air transport, electric power, insurance and banking. Competition from other materials and from foreign producers, greater complexity in production and defense requirements, increasing volume of business, and technological breakthroughs from research and development are some factors that foster the introduction of new techniques in these industries.

In other industries, technological changes will continue to be limited. Among these are apparel, furniture, footwear, foundries, and dairy. Consumer taste, preference for frequent style changes, custom nature of the work, job lot production, and dominance of small firms with little capital tend to retard the rate of mechanization.

Technological changes take place within a complex network of interrelated industries. All industries are affected not only by changes from within but also by changes that occur among purchasers of their output and suppliers of materials for processing. The substantial curtailment of ingot casting implicit in the growth of continuous casting in the steel industry, for example, will curtail demand for ingot molds, one of the large tonnage products of the foundry industry.

2. *"Automation," as technically defined, will become increasingly important in many industries, but changes along past lines of technological development will remain highly significant.* Computers, automatic controls, and transfer machines are being introduced gradually in many industries. Their application, as in the case of other technological changes, depends on an assessment of costs relative to possible future returns. Economic feasibility remains the governing consideration.

Continuing improvements in existing processes or products in some cases limit the introduction of more radical technological changes. In electric power, for example, reduction in the cost of coal through improved transportation tends to delay the introduction of nuclear power generation. The appearance of manmade materials for making shoes is stimulating leather producers to improve their competitive position. Because of such competition, the timing of many changes is often difficult to predict, and changes in one field often have unforeseen and far-reaching effects in others.

3. *Employment prospects in the industries studied are generally favorable.* The table shows the changes expected by 1970. Of the 40 industries, employment is expected to rise in 17, with about 26 million workers or about 77 percent of all employees in those industries covered by the study.

The prospects are less promising in 13 industries where employment by 1970 will probably be lower than in 1964. Increasing demand in these industries will not compensate for the reduction in unit labor requirements, and even

Employment in 1957 and 1964 and Prospects for 1970

Industry	Employment		
	1957 (thousands)	1964 (thousands)	Percent change
Industries where employment by 1970 will probably be higher:			
Air transportation	148.4	190.8	28.6
Apparel	1,210.1	1,302.0	7.6
Banking	602.9	764.4	26.8
Concrete, gypsum and plaster products	[1]140.1	172.1	22.8
Contract construction	2,923.0	3,056.0	4.6
Electrical machinery, equipment, and supplies	1,343.8	1,548.4	15.2
Federal government	2.217.0	2,348.0	5.9
Foundries	306.5	286.3	— 6.6
Furniture and fixtures	374.0	406.0	8.6
Glass containers	54.3	60.4	11.2
Instruments and related products	342.1	369.3	8.0
Insurance carriers	[1]813.6	895.2	10.0
Motor freight	804.2	919.8	14.4
Printing and publishing	870.0	950.5	9.3
Pulp, paper, and board	226.4	220.9	— 2.4
Synthetic materials and plastics products	[1]244.2	354.0	45.0
Wholesale and retail trade	10,886.0	12,132.0	11.4
Industries where employment by 1970 will probably be lower:			
Bakery products	302.5	289.9	— 4.1
Bituminous coal	229.8	136.0	—40.8
Dairy products	[1]319.1	288.6	— 9.6
Flour and other grain mill products	27.1	21.9	—19.2
Hydraulic cement	41.6	34.5	—17.1
Lumber and wood products	655.3	602.5	— 8.1
Malt liquors	77.4	61.9	—20.0
Meat products	333.1	313.6	— 5.8
Petroleum refining	153.9	113.9	—26.0
Railroads	985.0	665.0	—32.5
Textile mill products	981.1	891.1	— 9.2
Tobacco products	71.5	62.9	—12.0
Water transportation	[2]231.7	222.3	— 4.0
Industries where employment by 1970 will probably be only slightly changed, or is uncertain:			
Aircraft, and missiles and space vehicles	[1]848.0	790.6	— 6.8
Aluminum	65.0	76.4	17.5
Copper ore mining	32.3	27.1	—16.1
Crude petroleum and natural gas	344.0	289.4	—15.9
Electric power and gas	581.8	575.9	— 1.0
Footwear (except rubber)	235.0	213.3	— 9.2
Iron and steel	719.9	629.4	—12.6
Motor vehicles and equipment	769.3	755.4	— 1.8
Telephone communication	768.2	706.1	— 8.1
Tires and inner tubes	96.9	85.8	—11.5

[1] 1958.
[2] 1959.

with higher output, employment may decline. This group of industries employs about 3.7 million.

Projections for a third group, with about 4.1 million employees or 12 percent of the employment covered, show only a slight decline or a slight increase in employment by 1970, or the outlook is uncertain.

4. *Prospective technological changes will continue to reduce the proportion of jobs involving primarily physical and manual ability and to increase the need for jobs requiring ability to work with data and information.* No attempt was made to quantify these changes in this report, but several broad trends can be described.

The proportion of the labor force engaged in materials handling will continue to be reduced. A few operators of mechanized handling equipment or conveyors can often do the work done by a number of manual materials handlers.

Among operatives, faster and larger automatic machinery reduces the number employed per unit of output in jobs involving direct, step-by-step manual manipulation, loading and unloading, or tending of equipment. Increasingly, the function of the factory operative is to patrol a number of automatic machines and to be responsive to signals indicating breakdown.

In process industries, the typical operator will monitor a wide panel of control instruments and record information for interpretation. The control operator performs as a skilled watchman, with duties demanding patience, alertness to malfunctioning, and a sense of responsibility for costly equipment.

In many industries, maintenance and repair work is becoming increasingly important or is being changed as new types of equipment are introduced. Complex electronic equipment, such as numerical controls and computers, require specially trained electronic maintenance workers. On the other hand, routine maintenance on new equipment is often reduced by means of devices for automatic lubrication of machinery.

Technological advances may also result in new requirements for some skilled craftsmen. Instrumentation, for example, requires the flour miller to supplement his "rule of thumb" methods with a knowledge of more scientific procedures. New materials and processes require construction craftsmen, printers, and power plant operators to learn new skills and update their knowledge.

Electronic data processing (EDP) will reduce the relative proportion of routine office jobs, especially in repetitive manual recordkeeping work, but will require new and higher grade jobs to plan, program, and operate such systems.

The narrowing of opportunities in low-skilled work and the trend toward greater knowledge requirements in many fields of work underscore the importance of broad education and training as preparation for work. With the prospect of marked changes in jobs over his working life, the American worker will have great need for adaptability and flexibility in the years ahead.

5. *This study indicates the inevitability and pervasiveness of technological change and underscores the importance of developing adequate plans to facilitate manpower adjustment.* Management and labor have adopted a great diversity of measures, ranging from on-the-job retraining to comprehensive programs for job security. The coverage and scope of these measures vary from industry to industry depending on economic and other conditions. The government's training, counseling, and placement services, together with the Nation's educational system, remain the focus of efforts to prepare young persons who are entering the labor market and to assist unemployed adults to meet the requirements of advancing technology. Measures to maintain a high rate of employment remain the basic condition for the success of adjustment programs.

PART III. SCOPE, METHOD, SOURCES, AND LIMITATIONS

Scope of Reports

Industry Coverage. Major industries are covered in 40 separate reports. Some reports cover a group of industries: for example, tobacco covers both cigar and cigarette industries. The number of individual industries covered, i.e., four-digit Standard Industrial Classification (SIC) industries, is therefore much greater than 40. Employment in the industries covered totaled 33.8 million in 1964 or 58 percent of nonfarm employment.

The industries covered were selected so that most of the major branches of industrial activity, i.e., mining, construction, manufacturing, transportation, trade, utilities, finance, and government would be represented. Within manufacturing, most of the industries surveyed employ at least 100,000 persons. Agriculture and the service industries such as hotels and hospitals, are among major exclusions.

Content of Industry Reports. Each industry report deals with three broad aspects of change: outlook for technology and markets; manpower trends and outlook; and some issues and examples of labor-management adjustment.

The emphasis is on the outlook for technological changes. Major innovations in equipment, processes, and materials are described in terms of their relation to the older technology and to the proportion of employment affected. Innovations not yet fully tested are mentioned but are not extensively covered. The outlook for new products and for growth in the industry's total output over the next 5 years is evaluated in relation to past trends and to factors affecting future demand.

The descriptions of innovations indicate some advantages that are reported or claimed, such as laborsavings, quality improvements, fuel and material economies, greater accuracy, and new markets. Estimates of current and 1970–75 importance in terms of proportion of firms using the new technology or of total output produced by it are presented wherever such data are available. Factors affecting adoption of technical innovations, such as capital cost, industry structure, consumer taste, and government regulations are discussed. Trends in expenditures on new plant and equipment and on research and development which have an important bearing on the rate and direction of technological change are noted.

The manpower implications of technological change are discussed in terms of trends in employment and of changes in the structure and content of jobs. Occupations that are created and those that are decreased are identified wherever possible. Employment prospects for 1970 are indicated in qualitative terms, i.e., whether employment will be higher, lower, or about the same as in 1964.

The final section of each industry report describes briefly some problems of adjustment and some examples of formal and informal measures that are being used in the industry to ease the introduction of technological change. The extent of provisions in collective bargaining agreements pertaining to early retirement, severance pay, and similar measures and the nature of private and government training programs are noted briefly, wherever available. It is recognized that virtually every collective bargaining agreement relates in some way to job security, but the emphasis in this section is on recent specific efforts to adjust to advancing technology. This section is illustrative rather than comprehensive.

Method of Preparing Technological Forecasts

The preparation of technological forecasts involved research into published sources, consultation with experts, and analysis of statistical data.

Publications pertaining to technological trends, economic developments, and manpower problems in each industry were reviewed intensively. Technical and trade journals, government reports, books, trade association yearbooks, and reference works were sources of information about the current state of technology and important prospective developments. Annual reports from leading corporations in each industry were reviewed for information about new plants, processes, and products. Government studies of trends in productivity, employment, occupational requirements, and collective bargaining were analyzed. (A selected bibliography on technological advances and manpower implications in each industry is appended to each report.)

Interviews with experts were an important phase of the preparation. A few plants which have introduced important technological advances were visited to observe operations. Staff researchers also attended conferences, seminars, and trade shows. About 250 officials of companies, unions, trade associations, and government agencies were interviewed in preparing industry reports.

A preliminary industry report based on analysis of information assembled from various sources was prepared. This appraisal required first an estimate of the potential magnitude of the reduction in labor requirements per unit in a particular operation or department and an assessment of the impact of the change on the productivity of the industry as a whole. The proportion of total man-hours involved in the operation and how rapidly the change is introduced were important variables in making this assessment. In practice, the statistical data were rarely available for such refined estimation. Assessing the impact therefore became a matter of interpretative analysis based on all the available information about past and prospective trends.

The preliminary report presented projections of industry employment to 1970. Possible changes in demand for the industry's output as well as the impact of laborsaving developments were taken into account. Past trends in output and prospective market trends were the principal basis for projections. (Data used in making projections are discussed below.)

A critical step in final report preparation was a review of its validity and adequacy by industry experts. Preliminary reports were sent to 10 to 15 experts in each industry including officials of leading corporations (such as vice presidents in charge of research or manufacturing), union research directors, trade association directors, editors of trade publications, and government and university specialists. Their comments and suggestions were taken into account in the final industry report. Of the 453 individuals to whom preliminary reports were sent, close to 400 replied. Since these reports were often reviewed in some organizations by several staff members, the total number of reviewers was greater. Replies ranged from detailed reviews to general appraisals of the report as a whole. Some reviewers furnished additional information about technological trends. In a few cases, follow-up consultations clarified points of criticism and resolved differences of opinion. This review procedure was designed in an effort to assure that these studies reflect as closely as possible authoritative opinion about each industry.

Sources of Statistical Data and Projections

Statistical data pertaining to productivity, production, employment trends, investment, and R&D provide a quantitative basis for assessing the implications of technological change. They are shown in charts and tables and are analyzed in the text.

Productivity. Indexes of output per man-hour are available for 17 of the 40 industry reports. *Indexes of Output per Man-Hour for Selected Industries 1939 and 1947–63* (BLS Report 301), is the source for 15 indexes; indexes for two food industries are from *Marketing and Transportation Situation* (U.S. Department of Agriculture, Economic Research Service, February 1965).

For most industries, rates of change, based on the compound interest method, were computed for the periods from 1947 to 1957 and from 1957 to 1963 or 1964. These terminal years were selected because they were periods of fairly high rates of capacity utilization. The influence of the business cycle on the indicated rate of change is thereby reduced. These rates may differ from those calculated on the basis of the least squares trend of logarithms of the annual index numbers, which reflect the year-to-year changes rather than changes between terminal years.

Production. Production trends in each industry also are analyzed. Output indexes, developed by the Bureau's Division of Productivity

Measurement in conjunction with measures of trends in output per man-hour, were the basis of analysis in some industries. For many manufacturing industries, the Federal Reserve Board (FRB) indexes of production were used as indicators of the trend in output. The sources for these indexes were two FRB publications: *Industrial Production, 1957–59 Base* (Board of Governors of the Federal Reserve System, 1962), and *Industrial Production Indexes, 1961–64* (September 1965). For the nonmanufacturing industries, measures of output based on national income statistics or on data from regulatory agencies were utilized. Because these measures often are not consistent with concepts of output used in BLS productivity measurement, indexes of output per man-hour constructed from them may not be representative of productivity trends.

Various sources were used in projecting future trends in output. For a number of industries, projections presented in *Resources in America's Future,* by H. Landsberg, L. Fischmann, and J. L. Fisher, published for Resources for the Future, Inc., by the Johns Hopkins Press, 1963, are cited. Projections from government and trade sources also were used for some industries. The sources are cited in the text.

Employment. Employment data (all employees and production workers) for most of the industries covered are from the publication *Employment and Earnings Statistics for the United States, 1909–64* (BLS Bulletin 1312–2). For some industries, data on employment from the Bureau of Census *Annual Survey* and *Census of Manufacturers* were used to assure consistency with production and productivity series. Census employment series are noted in the text.

Projections of industry employment shown in this report are consistent with levels projected by the Bureau's Division of Manpower and Occupational Outlook and the Division of Economic Growth on the assumption of a 3-percent unemployment rate in 1970.

Investment and Research. Principal sources of statistics on expenditures for plant and equipment were the *Census* and *Annual Surveys of Manufactures* published by the Bureau of the Census. For nonmanufacturing industries, data from the Securities and Exchange Commission and the McGraw-Hill Co. were used. The National Science Foundation was the principal source of data on expenditures for research and development and employment of scientists and engineers in R&D.

Occupational Data. Data on the occupational distribution of employment in a number of industries are based on the *1960 Census of Population.* For some industries, *Industry Wage Surveys,* prepared by the Bureau's Division of Occupational Pay, provided data about the occupational structure. *The Occupational Outlook Handbook, 1963–64 Edition* (BLS Bulletin 1375) was an important source of information about occupational trends.

Adjustments to Technological Change. Statistical information on the prevalence of provisions in collective bargaining agreements which pertain to adjustments to technological change are available for a limited number of industries from the following studies by the Bureau's Division of Industrial and Labor Relations: *Severance Pay and Layoff Benefit Plans* (BLS Bulletin 1425–2, 1965); *Supplemental Unemployment Benefit Plans and Wage-Employment Guarantees* (BLS Bulletin 1425–3, 1965); and *Labor Mobility and Private Pension Plans: Study of Vesting, Early Retirement, and Portability Provisions* (BLS Bulletin 1407, 1964). Summaries of agreements in *Recent Collective Bargaining and Technological Change* (BLS Report 266, March 1964) and in the monthly BLS report, *Current Wage Developments* were also used.

Limitations and Qualifications

Some limitations of the study must be kept in mind. They indicate not only some qualifications of the information but suggest some areas for future research and improvement.

First, it should be recognized that projections of future technological changes are necessarily complex and uncertain. Efforts were made to avoid emphasizing spectacular but unrepresentative changes and to include all significant changes. Projections were based on information available in 1965 and reflect the opinions of industry experts as of that date. New technical and economic developments, not foreseen in 1965, may arise over the next 5 to 10 years which will require reevaluation of developments now pending. Changes in government expenditures for defense purposes, for example, could alter significantly the outlook in defense related industries.

Second, quantitative data about the extent, pace, and implications of technological change are fragmentary. Statistical information about the status of important developments, for example, is available for only a few industries and innovations, and data about their manpower effects are typically not available. Statements about the implications of technological change therefore, are based on judgment, approximation, and interpretative analysis of all the available information.

Third, projections of technological change by industry experts often are made without explicit reference to changes taking place in other industries. Yet a characteristic of advancing technology is the complex interrelationships among industries. Technological changes not only affect directly the industries where they are introduced but may have an indirect impact on industries which supply materials or fuels consumed or which produce a competitive product or service. In the future, the Bureau's research program on economic growth, which takes explicit account of the interdependence of industries, will provide a basis for improving estimates of future levels of output and employment.

Finally, this report surveys developments in a fairly large number of industries. Accordingly, the analysis of technological changes and their manpower implications in each industry has been deliberately made concise. More intensive research will be necessary to determine more fully the manpower implications of technological changes, such as their effects on productivity, the structure, content, and educational and training requirements of jobs, and the benefits and problems of various methods of adjustment. Future research may involve, for example, the collection of occupational information from advanced plants and the development of improved techniques for analyzing factors influencing the direction and pace of technological change.

PART IV. INDUSTRY REPORTS

The Copper Ore Mining Industry (SIC 102)

Summary of Outlook Through 1970

Production of copper ore is expected to continue to rise over the next 5 years. Most of this growth in output will come from the demand for copper due to the expanded activity projected for communications and building construction. Output per employee will probably continue to increase as equipment and methods are improved. Newly developed methods of mining, improved beneficiation techniques, larger and more powerful equipment, and a widening variety of automatic machines will be the primary technological advances.

Total employment will probably remain near current levels, the proportion of production workers continuing a slight decline. Occupations, skills, and job duties of workers are changing as new equipment and processes are being introduced. More truckdrivers and repairmen (automobile and electronic) will be needed. Union contracts with major producers, negotiated in 1964, provided supplementary unemployment and termination benefits.

Outlook for Technology and Markets

Production is expected to continue to increase at a significant rate. Output of copper ore increased by more than 3 percent a year over the 1947–64 period. The rate for 1947–57, however, was 4.1 percent, well above the 2.6-percent rate for the 1957–64 period. Because of increasing demand for copper arising from expansion in electronics, durable goods manufacturing, communications, electrical utilities, and residential construction, industry experts predict continued growth in output of copper ore through 1970.

Since the average amount of usable copper that can be obtained from a ton of copper ore has been declining, as richer deposits are exhausted, total output measured in terms of tons of recoverable copper is not increasing as rapidly as total tons of ore mined. The rate of growth for the 1947–64 period, in recoverable copper produced, was 2.4 percent per year. Increasing use of copper scrap and improvements in ore processing, however, are expected to become more important in compensating for anticipated decline in the grade of ore.

Extraction of ore by open-pit methods will continue to dominate copper mining. Eighty-two percent of copper ore came from open-pit mines in 1964 compared with less than 60 percent prior to World War II. It will continue to be the major method of mining ores because it is the most economical means of extracting ore deposits near the ground surface—the major types of ore supply in the United States. Block-caving and room and pillar mining are the two most important methods of mining underground deposits. These two low-cost, large-scale production methods accounted for approximately

Copper ore is loaded into an 85-ton off-highway truck.

12 percent of copper ore output in 1963. No substantial change in the relative importance of copper mining methods is expected in the next 5 years.

Conversion of ore haulage from rail to trucks continues to win acceptance. This is especially true in and around open pits where maneuverability and flexibility are important. The shift has taken place gradually over the past 15 years, becoming more accelerated in the past 5 years. In early 1965, only 4 of 18 major open-pit mines were using rail as their main haulage system. The switch to trucks eliminates tracklaying and moving crews, but requires more truckdrivers and automotive mechanics. One major producer estimates that conversion to truck haulage at one pit would result in total mining costs being reduced by as much as 12 percent.

Trend to larger size trucks may be tempered by individual conditions. Considerable progress continues to be made in increasing the capacity and horsepower of trucks in general use. Typical 30-ton trucks with 150 horsepower of 20 years ago have given way to 60- to 80-ton units with 700 horsepower. Trucks with up to 120-ton capacity are also being used. Research is now underway to determine the economies of particular conditions and maximum truck capacity. Because breakdown, maintenance, and repair of a few extra large capacity trucks may seriously delay haulage of ore, some producers may limit the capacity of trucks used to the more typical 60- to 80-ton units, even though a larger number of trucks will be required. A great deal of interest has centered recently around the possible use of electric wheel and diesel-electric trucks to gain added economic benefits through decreased engine wear, maintenance, and fuel costs. Several pits are using them on an experimental basis.

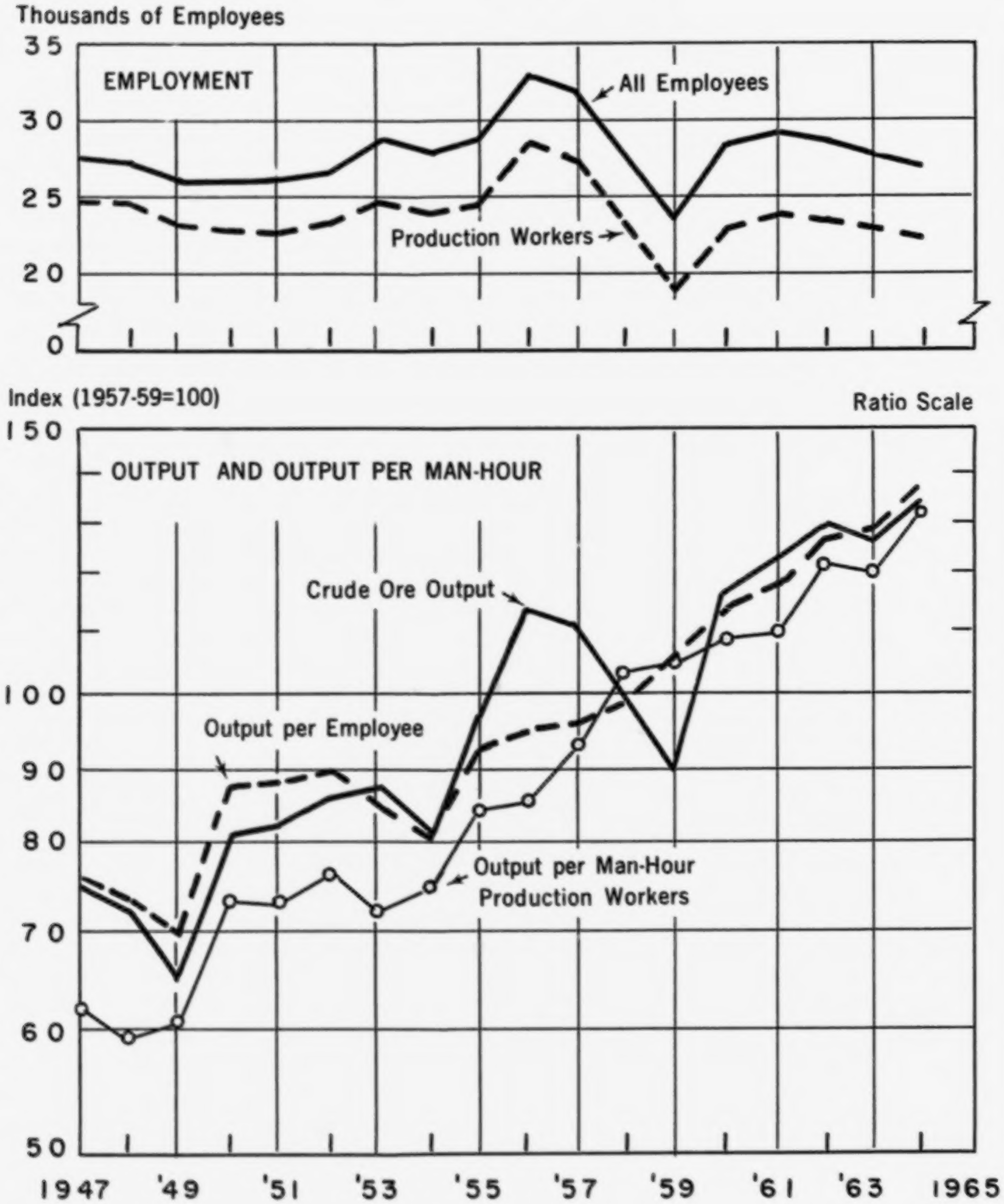
Train haulage will be retained for longer hauls. Trains are still heavily favored for distances of about 3 miles or more. Automatic controls make the use of trains more economical, allowing reductions in the size of operating crews from two to one. Unloading of railroad cars is expedited by improved techniques of dumping and made more automatic by remote-controlled positioning of cars. These innovations require fewer operating personnel and reduce requirements for laborers.

Mining equipment continues trend toward increased power and capacity. Skips which haul over 40 cubic yards, blasthole drills capable of drilling 15-inch holes, huge scrapers and loaders are examples of the trend that is expected to continue toward larger mining machinery. Shovels are also becoming larger. Ten- and 15-cubic yard capacity shovels are now common compared to 7- or 8-cubic yard shovels in use only a few years ago. Because of simplified controls and features such as automatic lubrication, work crews are being reduced. For example, shovel crews of three men are being replaced by one-man operators.

A highly automated copper concentrator, the first of its kind, serves as a model for future ore processing. The high degree of instrumentation in this concentrator, which became operative in 1964, allows significant reductions in operating personnel and enables the entire process to be monitored remotely by one man from a central control room. These operations include grinding, chemical and waterflows, flotation of ore, closed-circuit TV monitoring, and X-ray analysis of materials. In addition to substantial labor savings, the widespread use of instrumentation in this system allows greater control of quality through assaying of copper by fluorescent X-ray spectrography and atomic absorption devices on moving pulp streams. While a computer as part of this system is used to store data automatically, transmit data through printouts, and measure performance, it is not yet used to control the processes directly.

By grinding ore on ore, the grinding mills in this concentrator permit cost savings by eliminating the conventional use of steel grinding balls, eliminating undesirable steel particles entering the ore and obtaining a higher grinding capacity. Similar grinding mills have been installed since, and more are expected to be in-

EMPLOYMENT, OUTPUT, AND OUTPUT PER MAN-HOUR IN COPPER ORE MINING



Source: Bureau of Labor Statistics.

stalled in the near future. Their use, however, is limited to the processing of certain combinations of hard and soft ores.

New developments in drilling and blasting increase production levels and lower costs and manpower requirements. The angle-drilling technique, introduced in the late 1950's, will continue to grow in use in open-pit drilling. Improved fragmentation, reduction in amount of secondary blasting, and lowering of overall mining costs by as much as 10 percent are some of its economic benefits. Lower man-hour requirements in loading broken ore and in secondary blasting account for a large part of the decrease in cost. Ammonium nitrate and fuel-oil explosive, introduced in this country a decade ago, will continue to be the most widely used type of explosive in copper mining. Slurry and gel explosives, developed more recently, may become more important where a more powerful explosive is required.

Bacteria leaching could revolutionize copper recovery. The continuing depletion of high-grade deposits has created a need for more effective methods for recovering copper from low-grade ores. One promising process is the controlled use of micro-organisms in conjunction with conventional leaching (use of water-acid solution to dissolve copper minerals from ore) to increase significantly the rate of leaching reaction. Extensive research has already led to a substantial investment for future research and pilot operation by one company.

New devices and techniques for breaking rock are under development. The use of a high-frequency electromagnetic field for breaking rock is well into the development stage. A water cannon has been developed that shoots bursts of water at 50,000 psi, which is well above the breaking strength of most rock. Air decking, an improved blasting technique utilizing airspaces between charges in open-pit blastholes, is a further development for improving fragmentation. The use of nuclear explosives for stripping overburden for open-pit mining is being investigated, but application seems to be restricted to areas of semi-isolation and to overburden depths of 200 feet or more. Experiments are also being conducted to determine the feasibility of using nuclear explosives in conjunction with conventional underground block-caving mining. Significant changes in productivity and labor requirements may occur as these developments become commercially applicable.

Manpower Trends and Outlook

Growth in productivity is expected to continue at about the 1947–64 rate. Productivity, as measured by output of ore, should continue to increase at about the same annual rate of growth as in the 1947-64 period, over 3 percent for output per all-employee and over 4 percent for output per production worker man-hour. Output per all-employee increased at an annual average rate of 5.3 percent between 1957 and 1964, substantially above the 2.5-percent rate between 1947 and 1957. Output per production worker man-hour increased at about 4 percent during the earlier period and about 5 percent during the latter. In terms of copper recovered from ore, both output per all-employee and output per production worker man-hour from 1957 to 1964 were about the same as that for copper ores in the same period and somewhat lower in the 1947–57 period.

Employment is expected to remain relatively stable. Total employment increased from 27,500 in 1947 to 32,300 in 1957, an average annual rate of 1.6 percent. By 1964, employ-

	Average annual percent change
All employees	
1947–57	1.6
1957–64	−2.4
Production workers	
1947–57	.9
1957–64	−2.9
Output	
1947–57	4.1
1957–64	2.6
Output per employee	
1947–57	2.5
1957–64	5.3
Output per production worker man-hour	
1947–57	4.2
1957–64	5.1

ment had declined to 27,100, or a rate of 2.4 percent per year since 1957. As larger capacity, more highly automatic equipment is utilized, it will be possible for a work force averaging around the 1964 level to produce the anticipated larger output.

Changes in occupational structure will continue. The number of production workers increased at an average annual rate of 0.9 percent between 1947 and 1957, increasing from 24,700 to 27,100. During the period 1957–64, the number dropped at a rate of 2.9 percent per year, to 22,000. Production workers as a percent of total employment declined from 90 percent in 1947 to 84 percent in 1957. By 1964, the proportion of production workers declined to 81 percent, having slowed down considerably. This deceleration in trend is likely to continue.

Types of occupations continue to undergo change. Demand for mechanics, truckdrivers, electricians, technicians, and machine operators has increased while a large number of unskilled laborers, such as trackmen, have been virtually eliminated. Radio operators and electronics repairmen are expected to increase in importance as use of radio and TV become more widespread for communications and monitoring.

Some Issues and Examples of Adjustment

In-plant training programs are being used by some companies to ease the impact of technological change. For example, during a recent changeover from rail to truck haulage, one company, in close cooperation with the union, established an apprenticeship program for mechanics and training courses for drivers. Displaced employees were selected for these programs on the basis of aptitude, although few had any previous experience in either of the two jobs. Another company which recently introduced two-way radios in mobile equipment and closed-circuit TV systems for pit monitoring, set up training programs for both operators and maintenance personnel.

Shortage of underground copper miners may be met by relocating displaced coal miners. Although the two mining methods differ considerably, one copper producer has recruited over 550 displaced coal miners from Appalachia to meet a labor shortage in its underground facilities. Because of an expected continued shortage of copper miners, the program to relocate displaced coal miners is expected to continue.

Negotiations continue to involve provisions to lessen automation impact. Agreements in 1964 between union and major producers contain the stipulation that a permanent employee, normally one on the job 90 days or more, will not be laid off because of automation, technological changes, or new work methods. The latest contracts also generally contain, for the first time, provisions for supplemental unemployment and severance pay benefits. These provisions provide for setting up a fund for each employee, to be withdrawn during layoffs or paid in a lump sum on retirement to supplement the worker's regular pension.

Selected References

Technological Developments

Engineering and Mining Journal (Issue on Open Pit Technology), November 1964, pp. 81–101.

McMahon, A. D. *Copper, A Materials Survey,* Bureau of Mines, IC 8225, 1965. 340 pp.

"Mining Technology in 1964," *Mining Engineering*. February 1965, pp. 91–99.

Orr, David H. Jr. and Felix G. Berra. "One-Man Remote Control Rail Haulage," *Mining Engineering,* April 1965, pp. 75–79.

Russell, Paul L. "Stripping Overburden With Nuclear Explosives," *Mining Engineering,* June 1964, pp. 76–80.

Sutton, J. A. and J. D. Corrick. *Leaching Copper Sulfide Minerals With Selected Autotrophic Bacteria,* Bureau of Mines, RI 6423, 1964. 23 pp.

Wideman, F. L. "Copper," *Minerals Facts and Problems, 1965 Edition,* Bulletin 630, Bureau of Mines.

——. "Copper," *Minerals Yearbook,* 1964, Vol. 1, Bureau of Mines, 1965.

Wimsley, W. H. "The Open Pit Mining Industry Today," *Mining Congress Journal,* February 1965, pp. 36–39 and 41.

Wraith, William Jr. and F. G. Fulmor. "Anaconda's Butte Concentrator," *Mining Engineering,* May 1964, pp. 54–78.

Manpower Trends and Adjustments

Bogart, John R. "Electronic Eyes and Ears Monitor Pit Operations," *Metal Mining and Processing,* March 1964, pp. 48–52.

Crawford, J. O.; C. A. Garner; and G. A. Kniepp. "From Coal to Copper," *Employment Service Review,* Bureau of Employment Security, October 1964, pp. 28–30 and 33.

Current Wage Developments, No. 201, Bureau of Labor Statistics, Sept. 1, 1964, pp. 3 and 22–23.

Shilling, R. W. "Conversion From Rail to Truck Haulage at the Chino Pit," *Mining Congress Journal,* April 1964, pp. 29–32 and 43.

The Bituminous Coal Mining Industry (SIC 12)

Summary of Outlook Through 1970

Coal output is expected to rise significantly through 1970. Most of the increase in demand for coal will come from the electric power industry, where cost of coal for fuel is being lowered by improvements in energy transportation, such as high voltage transmission of electricity and unit train shipments of coal, as well as advances in mining technology. Among the principal technological developments are: More intensive use of continuous mining machines, the possible spread of longwall mining methods, and increasing utilization of giant earth moving equipment by surface mines.

Continued increases in output per man-hour are projected through 1970, due in part, to increasing concentration of production in more efficient mines; in part, to introduction of more effective mining techniques. Continued declines in employment are also expected, particularly in mines unable to meet increasingly stringent competitive conditions in the coal industry.

Reduced retirement age, liberalization of pensions, and voluntary relocation of displaced miners are among the measures being used in efforts to modify the impact of declining employment.

Outlook for Technology and Markets

Output of coal is expected to continue a rise which began in 1962. Coal output of 487 million tons in 1964 exceeded 1963 production by more than 28 million tons. One industry source estimates production at 595 million tons by 1970 and several sources project an annual output of 800 to 900 million tons for 1980. Based on 1964 production, these projected levels represent an increase of between 3 and 4 percent compounded annually. A growth rate of 2.9 percent has been maintained since 1958.

Improved competitive position is reflected in the rising demand for coal in electric utility and export markets. Projections of increased coal production are founded on the growing demand of the electric power industry (coal's most important market) and on an increasing export demand.

The National Power Survey (1963) by the Federal Power Commission estimates that by 1980, almost 500 million tons of coal will be required for power generation alone. A substantial part of this expansion in demand is expected from the growth of extra high voltage transmission of electric power, a development stimulating construction of generating plants at the mine mouth. The National Power Survey also predicts about 25 percent of all new generating capacity in 1980 to be mine-mouth plants.

According to a study made for the U.S. Department of the Interior's Office of Coal Research, export sales may rise from 47 million tons in 1963 to between 80 and 138 million tons by 1970. Other export projections range between 140 and 150 million tons. Estimates of comparative productivity in 1963 showed U.S. output per worker more than five times higher than the highest average for European nations.

Unitized trains widen markets for coal. Unitized trains haul coal at bargain rates directly from a single producer to a single consumer. They carry 7,000 to 10,000 tons per trip, travel at near passenger train speeds, bypass all classification yards, and save an average of $1.50 a ton on the delivered price of coal to users, in many cases gaining a competitive advantage over other fuels. One large utility, for example, will use 2 to 2.5 million tons of coal annually at a plant originally intended to use oil.

Developed in 1960, unit trains by 1965 were hauling 25 percent of total railroad coal tonnage. Estimates are that up to 50 percent of all coal hauled by railroads in 1970 may be in unit trains. New mines designed to supply a single customer by unit train shipment, plans for trainloads of 15,000 to 20,000 tons, and more advanced "integral" unit trains owned by utility companies, all tend to support forecasts of unit train shipments of coal by 1980 at about one-half the present cost of oil by pipeline. Other developments in coal transports, such as improved barge tows and possibly coal slurry pipelines, also may advance the competitive position of coal in particular markets.

Use of continuous mining machines is increasing. The 1,030 machines in operation in 1963 represented a net increase of 69 units over 1962. Continuous mining machines produced 39 percent of underground coal in 1964, as compared with 27 percent at the beginning of the decade. One industry expert predicts that continuous mining machine production will reach 49 percent of total underground output by 1970.

In 1963, continuous mining machines were used by 332 mines, while 139 mines used only continuous mining machines. Productivity in those mines using only continuous mining machines was 8 percent greater than in mines using conventional mechanical methods and 25 percent greater than the average for all underground mines, including hand loaded mines.

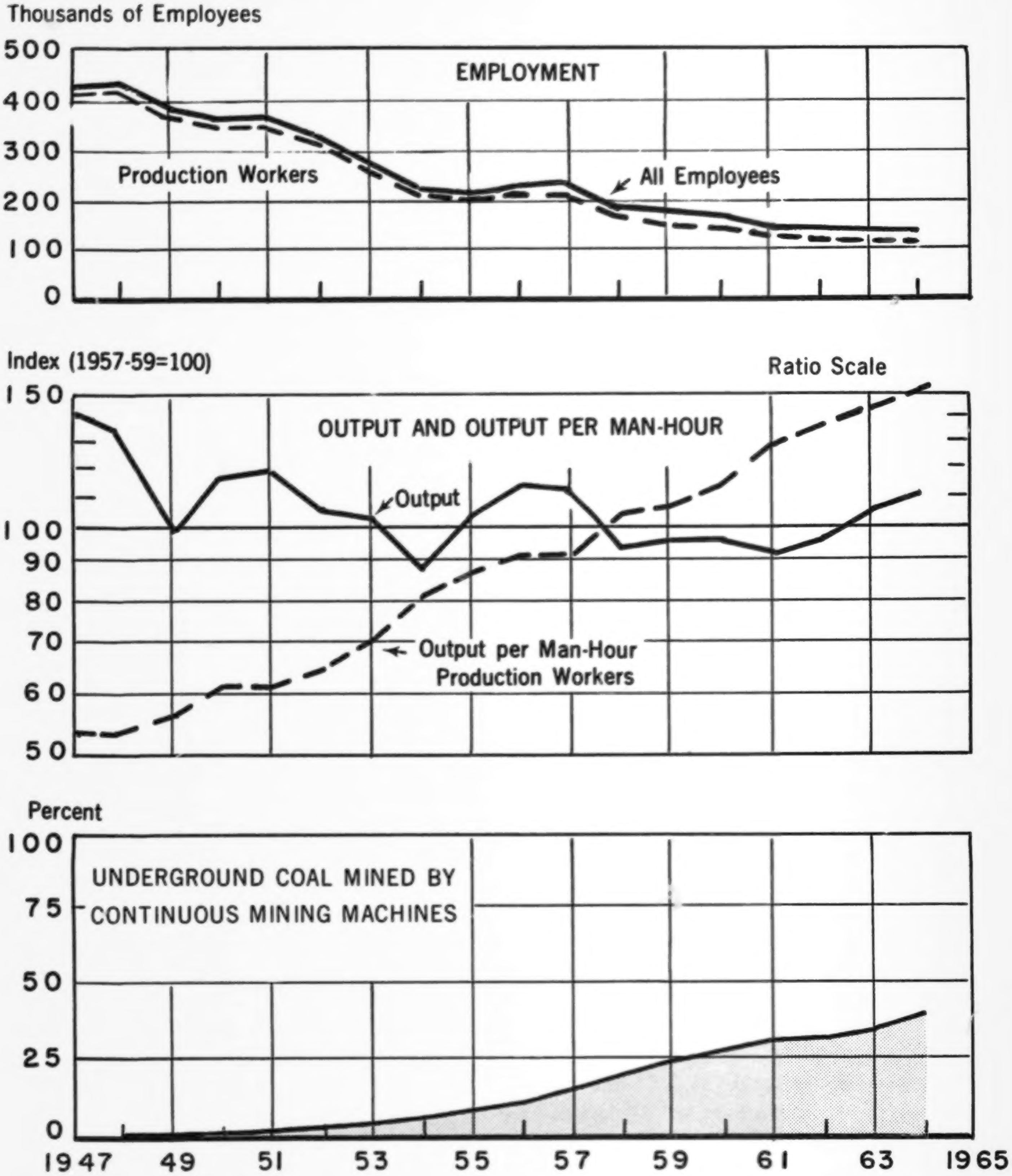
Other technological advances achieve better machine utilization. "Continuous" mining machines are currently estimated to be in actual production less than two-thirds of the time. Modular constructed machines are returned to service more quickly after breakdown, as entire sections are removed and replaced and the damaged parts then repaired without interrupting production. Improved conveyor systems, now being installed, remove coal faster with less idle time for the machine. Improved reliability of AC-powered equipment has caused a swing to AC current in mining. Experts believe very few new mines using DC current will be opened. Other improvements that result in greater machine utilization include transistorized equipment control circuits (less prone to failure), and improved lighting and dust control equipment.

Greater capacity stripping equipment extends scope of surface mining. A 180-cubic yard shovel, soon to become the largest available, will permit the removal of thicker overburden, thus helping to extend the reach of surface mining. As late as 1960, the largest shovel was 85 cubic yards. Also significant for greater productivity are the steady increases in power and average capacity of smaller shovels and increased use of auxiliary equipment such as trucks, bulldozers, coal drills, and rippers. In 1963, shovels and draglines of more than 6 cubic yard capacity constituted 16 percent of all shovels, compared with 12 percent in 1958. These improvements have helped surface mines increase their share of total coal output from 28.3 percent in 1958 to 33.9 percent in 1964. Output per man-day rose from 21.5 to 28.7 tons—more than double the productivity of underground mines. The rates of increase in the percentage of coal from surface mining and in the productivity of such mines are expected to decrease as average overburden becomes thicker.

Longwall mining with self-advancing roof supports could be a basis for continuing productivity increases. In longwall mining, coal is cut from a face of 300 to 1,000 feet as compared with 9 to 30 feet in room and pillar mining. Pushbutton operated, hydraulically powered roof supports advance toward the surface to be mined, as a cutter, traveling on rails atop the face conveyor, removes the coal and dumps it onto the conveyor. The roof is permitted to cave in behind the machinery as it moves for-

Miner on top of twin trucks dramatizes bucket size of new stripping shovel.

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND UNDERGROUND COAL MINED BY CONTINUOUS MINING MACHINES IN BITUMINOUS COAL MINES



Sources: Underground coal mined, Bureau of Mines; employment, output and output per man-hour, Bureau of Labor Statistics.

ward. Permanent roof supports are thus needed only in passageways.

The repetitive nature of the longwall production cycle lends itself well to automatic operation. In Great Britain, for example, several remotely operated longwall faces (ROLF) are in operation, controlled by single operators at electronic control panels, located 60 feet or more from the surface to be cut. Plans to substitute computers for the operators are well advanced.

According to industry experts, face productivity of U.S. longwall mining has ranged between 45 and 66 tons per manshift. Continuous mining machines in room and pillar mines have done as well, but under generally better mining conditions. One company operating a longwall system claims a 25-percent saving in labor cost over continuous mining under the same conditions, and a 45-percent reduction in total costs compared with conventional equipment.

Application of mechanized longwall mining to U.S. coal beds began in 1951 as an experiment conducted jointly by the Bureau of Mines and private industry. By 1963, the new system produced 816,000 tons. Six longwall mines were in operation in 1964 and operation of additional mines began in 1965. Among the major impediments, however, to rapid diffusion of longwall mining in the United States are the very high initial outlays for equipment and presently long time lag between the beginning of construction and commercial production.

Research and development expenditures are rising. A recent survey by U.S. Department of Interior's Office of Coal Research indicated that annual expenditures for coal research by all interested organizations amounted to between $20 and $25 million in 1964, as compared with $17 million disclosed in a 1955 survey. Since its inception in 1960, the Office of Coal Research has awarded about $17 million in contracts. During the same period, expenditures by the Bureau of Mines for coal research amounted to $40 million.

Key research opportunities exist in discovering methods of reducing the cost of mining, transporting and utilizing coal resources in the electric power industry, and in developing low-cost methods of converting coal into liquid and/or gaseous fuels. Other R&D efforts are directed toward making lignite and other low-grade coals profitable to use. Low-grade coals constitute about 60 percent of U.S. reserves, and satisfactory conclusion of such research, combined with modern energy transportation methods, could enlarge the markets for these products and open up new coal mining employment opportunities in western States.

Expenditures for new plant and equipment are increasing. Estimated 1964 expenditures of about $350 million (based on a 6-month survey by a leading industry journal) are near the highest ever registered and may be compared with annual averages of $265 million between 1950 and 1957, and $130 million between 1957 and 1963. Annual capital expenditures are expected to remain high in the immediate future and may rise as capacity is expanded to meet increased market demands. Capital investment per ton in surface mines was more than double that of underground mines in 1964.

New technology is changing the structure of industry. The new technology favors larger producing units. Large mines account for an increasingly greater share of total output. Coal mining companies also have tended to merge into larger companies, in part to meet higher capital requirements. At the same time, however, the existence of many unemployed miners willing to work for less than union wages has prompted the opening of a great many nonunion mines, some of which are too small to be counted in official production and employment data.

Manpower Trends and Adjustments

Productivity is expected to grow at a rapid rate. Output per man-hour increased at an annual average rate of 7.6 percent between 1957 and 1964 compared with a rate of 5.6 percent between 1947 and 1957. Another measure of productivity, "tons per man-day", increased from 12.8 to 16.8 tons between 1960 and 1964, about 1 ton per year. If the annual increase in tons per man-day reached 1.5 tons, output per man-day would amount to almost 25 tons in 1970. Increased productivity is due to the tendency toward concentration of production in more efficient mines as well as a general increase in efficiency.

Employment decline is expected to continue but at a lower rate. Between 1947 and 1964, employment fell by 289,600 jobs; 195,800 jobs were lost in the first 10 years; 93,800 during the last 7. Employment averaged 136,000 in 1964. At current annual productivity rates, each million tons of increased demand is the rough equivalent of 300 additional man-years of employment. Nevertheless, by 1970, employment in bituminous coal mining is expected to contract further as increases in productivity more than offset increases in demand.

	Average annual percent change
All employees	
1947–57	−6.0
1957–64	−7.2
Production workers	
1947–57	−6.4
1957–64	−7.9
Output	
1947–57	−2.3
1957–64	− .1
Output per production worker man-hour	
1947–57	5.6
1957–64	7.6

Work in mines is becoming steadier, more hours per week, more days per year. The mine workweek has risen irregularly to 39.3 hours in 1964 —3.5 hours longer than in 1960. Average weekly hours are expected to continue this gradual rise as the demand for coal increases. The average number of days worked per year will probably continue increasing also. The average of 225 days worked in 1964 was the highest since 1948; 20 days more than in 1963. Industry estimates of an attainable work year are about 240 days; the Bureau of Mines, however, estimates capacity on the basis of 280 days per year.

Changes in occupational structure are resulting from new methods of mining. The ratio of nonproduction workers to all employees is increasing. In 1964, nonproduction workers constituted 12 percent of employment as compared with 4.5 percent in 1950 and 11.5 percent in 1960.

Experts believe that by 1970 continued mechanization will have caused a shift in the occupational groupings of underground production workers resulting in about a 10-percent increase in maintenance workers and a 10-percent decrease in face workers. In 1962, maintenance workers comprised approximately 19 percent of underground mining employment; face workers, about 50 percent. The other 31 percent of workers in underground mines consisted of nonsection underground workers such as haulage, ventilation, and construction men, and outside workers such as tipple operators, truckdrivers, and car droppers.

Recent liberalization of eligibility requirements and benefit amounts for retirement may cushion employment decline. Beginning in 1965, the age at which workers may retire on full benefits was lowered from 60 to 55 years and the service requirement from 30 years to 20. Industry experts estimated that as a result, about 10,000 miners would be added to Welfare and Retirement Fund rolls. At the same time, payments to retired miners from the Fund were raised to $85 monthly (from $75).

Mineworkers have increased job security. The 1964 wage contract between the United Mine Workers of America (Ind.) and the Bituminous Coal Operators Association continued a traditional emphasis on higher wages. However, provisions to improve job security included the substitution of minewide seniority for job classification seniority. The contract also provided for a staggered vacation period, permitting 52 weeks of operation in the coal industry in order to enhance the security of coal miners by insuring that the industry will be able to fully utilize all of the new techniques and meet, to the fullest possible degree, the needs of its customers.

On-the-job training for operating and maintenance personnel is being expanded. As mining becomes more highly mechanized, formal and on-the-job training in mining methods, as well as in safety, are being introduced. Research sponsored by the American Mining Congress, for example, has found that the proper training of continuous mining machine operators can increase face crew output by substantial amounts. Another example is the training of mine mechanics, accustomed to repairing

DC equipment, to work on AC electrical equipment which is being installed in increasing amounts. Some companies are providing formal course work in electrical theory as well as its practical application.

Government retraining programs are aiding displaced miners. About 600 former coal miners were among the approximately 9,000 persons in Appalachia who have secured training under the Area Redevelopment and Manpower Development and Training Acts, as of 1964. Most of the miners were trained for other skilled jobs.

A program for relocating displaced coal miners in hard rock mining areas of the West is expected to grow. Recruitment of bituminous miners has started in Virginia, West Virginia, Pennsylvania, and Kentucky to meet a shortage of hard rock miners in the Butte, Mont., area. Since the program began, 220 workers from West Virginia alone have been recruited and the State had requests for 200 more during 1965.

Labor and management are working to improve the industry's market outlook. The UMWA is continuing to cooperate with coal producers, electric utilities, and railroads in the National Coal Policy Conference to accelerate the expansion of coal markets through such means as promoting increased consumption of electricity and working for continued restrictions on the import of residual fuel oil.

Selected References

Technological Developments

Perry, Harry W. *Revolution in Coal Transport—Is it Near?* A paper delivered before the Symposium on Coal of the American Association for the Advancement of Science, Philadelphia, 1962.

U.S. Department of the Interior. *Report to the Panel on Civilian Technology on Coal Slurry Pipe Lines,* May 1962 (Mimeo).

Snouffer, R. D. and Hansen, Victor D. "The Unit Train, Planning, Operating, Financing," *Coal Age,* March 1964, pp. 54–61.

"How Tunnelton Designed for Unit Train Shipment," *Coal Age,* April 1964, pp. 78–87.

Woomer, J. W. *New Frontiers in the Coal Mining Process.* Paper delivered before the Coal Symposium of the American Association for the Advancement of Science, Philadelphia, 1962.

Federal Power Commission. *The National Power Survey,* Washington, October 1964.

Evans, M. Albert. "Longwalling with Powered Roof Supports," *Coal Age,* September 1963, pp. 82–90.

Shupe, D. B. "Longwall Progress at Eastern Associated Mines," *Coal Age,* September 1964, pp. 76–78.

Selected References—Continued

Manpower Trends and Adjustments

Technological Change and Productivity in the Bituminous Coal Industry, 1920–1960 (BLS Bulletin 1305, 1961).

Industry Wage Survey, Bituminous Coal Mining, November 1962, Pts. I and II (BLS Bulletin 1383, 1963).

"The Coal Miners and the New Coal Contract," *Monthly Labor Review*, May 1964, p. III.

Sall, George W. "Advancing Technology Saves an Industry," *Mining Congress Journal*, February 1965.

Vogely, William A. "Technological Change and Demand," *Monthly Labor Review*, August 1964, pp. 891–892.

Christenson, Carroll L. *Economic Redevelopment in Bituminous Coal*, Boston, Harvard University Press, 1962.

The Crude Petroleum and Natural Gas Industry (SIC 13)

Summary of Outlook Through 1970

Over the next few years, output is expected to increase at a faster rate than in the past 10 years. Drilling activity is expected to rise slightly, and production of oil and gas to continue a steady increase. Major technical developments are taking place in all phases of the industry, including advances in offshore operations; in drilling, both offshore and on land; in secondary and thermal recovery from heavy oils; in recovery from shale oil and tar sands; and in gas processing, storage, and transportation. Wider application of computers and automatic control is anticipated. Employment is likely to be moderately lower in 1970.

Outlook for Technology and Markets

Some improvement is expected in the industry's slow rate of growth in production. The industry includes exploration, drilling, oil- and gas-well operation and maintenance, operation of gas plants, and the operations of gathering lines. Total production of this industry, according to the Federal Reserve Board index, grew at an average annual rate of 4.6 percent between 1947 and 1957, and only 1.1 percent a year between 1957 and 1964.

The rate of growth in crude oil output between 1947 and 1957 averaged 3.5 percent annually, compared with a rate of 1 percent between 1957 and 1964. New industrial markets for natural gas and gas liquids, and conversion by utilities to natural gas following construction of pipeline networks, resulted in an increase in the rate of output of 8 percent annually between 1947 and 1957. The average increase in output of 4.8 percent a year between 1957 and 1964, may be increased somewhat as new uses and products are developed.

Oil production is being automated rapidly by means of a method called "lease automatic custody transfer" (LACT). LACT equipment, introduced in 1955, includes an electrical and pneumatic system of instruments and controls for the pumps, treating equipment, storage tanks, and gathering lines used to operate oil wells. Using a LACT system, oil is automatically pumped, sampled, monitored, metered, and transferred through treating facilities to transmission pipelines for shipment to refineries. While initially, LACT units were installed on individual leases, systems for transferring the production of adjoining leases or entire fields are being introduced.

By the end of 1963, there were more than 1,500 LACT units handling about 50 percent of crude production in Colorado, Kentucky, Utah, and Wyoming. LACT has been adopted more rapidly by large producers who have more leases and can be more flexible in the introduction of new equipment. The greater economies from large operations are facilitating the trend towards LACT centralized operations.

Computers are being introduced in conjunction with centralized LACT systems. One new LACT system being installed will use a digital computer for automatic remote control. As many as 2,000 wells in this system can be monitored and controlled from a central location. Another installation is monitoring 270 operating wells in five isolated oil fields as far away as 160 miles from the company's operating center. The system monitors performance and logs data on a continuous basis.

According to surveys by the *Oil and Gas Journal*, the largest savings achieved by LACT systems have come from reduction of labor spent in manual gaging and switching of tanks. Capital investment is saved, since fewer storage and transfer tanks are needed. It is claimed that substantial savings are also realized with LACT through greater accuracy of measurement and better quality control and equipment maintenance. The advantage of the computer, added to the already great savings in labor and investment achieved by using automatic devices, is greater control over the system and an increased ability to handle detail.

Applications for computers are growing. Computers are being introduced in exploration, discovery and drilling, for data logging and analysis; in recovery and pipeline transfer operations for program scheduling; and in engineering and research for process simulation and systems analysis. The number of digital computers for process control in use by the industry increased from three at the end of 1963 to nine by March 1965.

Data-processing systems are also being introduced for storage and retrieval of information related to research and exploration. One such system will include information on 500,000 oil and gas wells in a six-State area. Referred to as the Mid-Continent Well Data System, it will be operated on a share basis by oil companies in the area. In another system, stored geophysical data can be recalled, sorted, and calculated with simplified programing so that scientists can use the system without programing specialists. Such systems, in addition to saving labor and paperwork, give the user greater control over a wider range of material and free him from routine duties.

Exploration and drilling operations are becoming more efficient. There is an increasing trend toward deeper exploration and more thorough analysis of information on older fields. Improvements in discovery techniques utilize electrical, gravimetric, magnetic, and seismic methods. Aerial photography, or photogeology, is using infrared techniques and efforts are being made to apply lasers for scanning. Use of computers for processing geophysical data in discovery operations has been increasing. Electronic data processing is being used with seismic instruments and continuous logging.

As drilling activity has declined, there has been greater attention to reducing operating costs. New deep drilling equipment, including slim hole equipment, the turbo-corer, percussion drilling, the downhole electric motor, and flexible drill stem, are some of the methods being developed to make deeper operations more economical.

Drilling and servicing operations are being facilitated by using lighter equipment, including aluminum drill pipe and gas turbine power plants which make possible prefabricated and portable drilling rigs. Aluminum drill pipe is being used, especially in deeper wells, because it is lighter, more elastic, and more corrosion resistant than steel pipe. Automation of drilling operations is being extended by use of automatic pipe handling systems and electronic instrumentation including continuous monitoring and sampling.

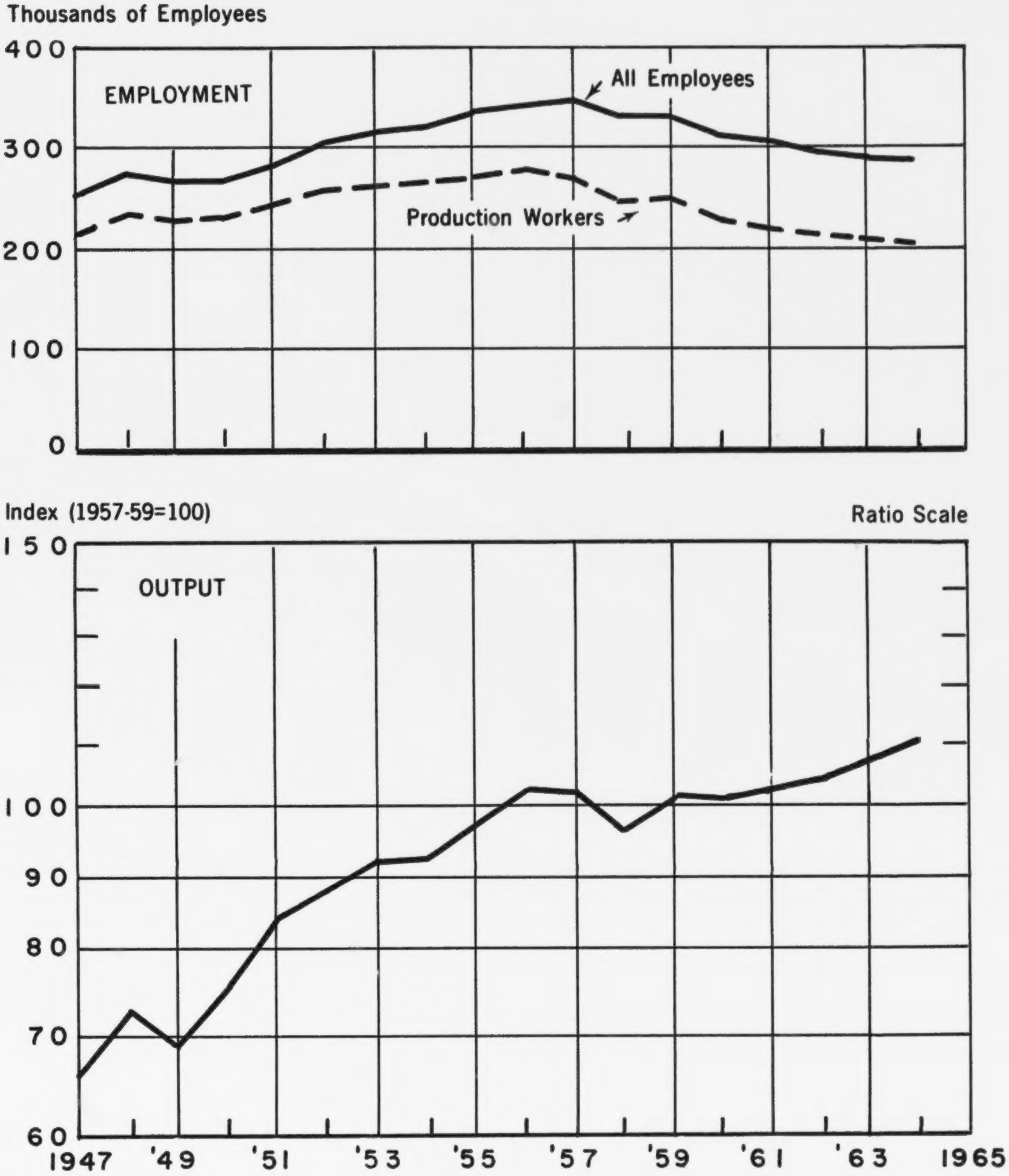
Improved techniques are being used in oil well servicing, secondary recovery, and development of new oil deposits. Increasing attention is being given to maintaining pressure at producing wells by various techniques which include the secondary recovery of older fields and the recovery of heavier oils. In addition to the injection of water or gas or combinations of both, new developments include the use of a range of chemical solutions, enriched gas to maintain well pressures close to original levels, and thermal methods.

Since 1952, there has been a steady increase in thermal projects using heated water, steam, and underground combustion. In 1963, there were about 100 such projects and about 20 new projects were being started. Forcing steam at about 400°F through a special injection well into the formation has been found to increase production by about 10 times. Combustion or in situ fireflooding recovery involves the injection of gas and air into the oil bearing formation. In one such project, involving injection wells and 55 producing wells in a 480-acre area, production was increased in some wells by 20 times.

Secondary recovery of older fields accounted for about 17 percent of total production in 1950, increased to 33 percent in 1963, and is expected by the U.S. Bureau of Mines to rise to 38 percent by 1970. Efforts are being made to apply thermal recovery methods to the primary production of heavy oil deposits in California, Wyoming, Oklahoma, Texas, Missouri, and Kansas where large reserves of crude oil are too heavy to be produced by conventional methods.

Offshore activities are increasing rapidly. Offshore wells drilled increased from 248 in 1954 to 707 in 1963. Over 2,700 offshore wells produced about 175 million barrels of oil, an increase of more than 500 percent over 1954, and 767 billion cubic feet of gas, an increase of almost 900 percent over 1954. Offshore areas of Louisiana are major centers of operations, and drilling in the area is projected to increase

EMPLOYMENT AND OUTPUT IN THE CRUDE PETROLEUM AND NATURAL GAS INDUSTRY



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board.

about 3 percent annually through 1970. Texas and California also have offshore operations and some development is underway in Alaska, Oregon, and Washington.

Improvements in offshore technology are making possible the expansion of operations into deeper waters beyond State jurisdictions, on leases from the Federal Government. Beginning at about 40 feet in 1950, drilling is now carried on in water as deep as 600 feet with possible future depths of at least 1,000 feet. A change from stationary platforms to mobile drilling rigs and subsea wellheads, oil storage, and pipelines has extended the range of drilling and production.

Advances in subsea working methods and equipment include the use of remote control systems and development of work submarines and diving bells. Divers have extended their working depth to 500 feet and it is claimed that improvements in equipment in a few years will enable men to work at 1,000 feet. However, it is claimed that new robots—mechanical apparata manipulated from the surface—are faster, more agile, can do heavier and more complex work for longer periods and at greater depths, and with greater freedom from interruption in rough weather. Television is being used to monitor robot underwater operations.

Gas processing capacities are growing rapidly. The number and size of plants for treating natural gas (elimination of impurities) and for producing gas liquids have shown steady increases. There were 839 plants in 1964, with an average output of 66.3 million cubic feet a day, compared with 783 plants averaging 60.6 million cubic feet a day in 1962. Most new gas processing plants are larger, are more highly automated, and have lower maintenance requirements. The new plants, using refrigerated absorption, produce liquids more efficiently and with lower operating temperatures.

The increasing production of natural gas and gas liquids is made possible by rapid growth in transmission and storage capacity. Storage capacity of underground pools for natural gas increased 15 times between 1947 and 1963; underground storage capacity for gas liquids grew from about 200,000 barrels in 1950 to nearly 98 million barrels in 1963.

Research and development (R&D) activities are increasing. Development of oil shale deposits in Colorado, Utah, and Wyoming and the tar sands of Alberta, Canada, is a major area of research activity. Although years of R&D apparently are making commercial production feasible, these sources are expected to have only a minor impact on production in the next 5 to 10 years.

From the oil shale deposits (marlstone that contains kerogen) having an estimated reserve of 1 to 2 trillion barrels, about 80 billion barrels of oil are believed to be economically recoverable using existing technology. Ability to exploit these deposits would increase known reserves manyfold. Separation methods being considered include heating mined shale either by cooking in a retort, by burning, or by passing heated gases or liquids through the shale. Another possibility is in situ combustion in which the shale is fired as situated underground. A number of oil companies are engaged in research on commercial methods for producing oil from the Alberta tar sands, reserves of which are estimated at 300 billion barrels.

Other activities include R&D on tools and instruments for exploration, drilling, and extraction. Experimental projects by government agencies are providing more advanced equipment and methods. The National Science Foundation has committed about $72 million to Project Mohole. The Atomic Energy Commission, in conjunction with its underground testing program, also is providing information that is useful for advancing industry technology, and the U.S. Bureau of Mines conducts and supports research and development on a wide range of drilling and recovery problems.

Manpower Trends and Adjustments

Employment is likely to decline moderately. Total employment in the crude petroleum and natural gas industry declined from 344,000 in 1957 to 288,600 in 1964, an average annual decrease of about 2.4 percent. During 1947–57, employment had increased. The faster growth of output over the next few years is not expected to be sufficient to offset improved methods, resulting in a moderate decline in employment.

	Average annual percent change
All employees	
1947–57	3.3
1957–64	−2.4
Production workers	
1947–57	2.4
1957–64	−3.8
Output	
1947–57	4.6
1957–64	1.1

Production worker jobs have been declining more rapidly than total employment. As a percent of total employment, production worker employment fell from 77 percent in 1957, to about 70 percent in 1964. Between 1950 and 1960, according to the U.S. Bureau of the Census, the proportion of professional and technical workers increased from 9 to 14 percent, while laborers declined from 51 to 41 percent.

The introduction of LACT systems probably will mean a greater decline of pumpers than of other occupations in extraction operations. The duties of pumpers, an occupation accounting for half of the field employment in 1960, involve adjusting valves, reading meters, making daily production reports, and checking pressures in gaging and switching of tanks. Many of these duties under the LACT system are performed automatically and are subject to remote control.

With decreases in drilling activity, total employment in drilling oil and gas wells declined. Roughnecks, who perform the least skilled duties in drilling operations and constituted the largest occupational group in drilling in 1960, have experienced considerable declines. Future increases in drilling activity may result in shortages in specific occupations such as rotary drillers, although employment levels are expected to remain low.

Some union-management agreements contained job security provisions. Of the 21 major agreements studied (effective in 1965), four contained provisions for severance pay. In addition, 12 of the agreements contained provisions concerned with reduction-in-force procedures, including job transfer rights, and 10 specified limits on minimum work crew size.

Selected References

An Appraisal of the Petroleum Industry of the United States. U.S. Department of the Interior, January 1965.

Farrar, G. L. "Computer Control in the Oil Industry," *The Oil and Gas Journal*, Oct. 26, 1964, pp. 89–119.

Farrar, G. L. "Petroleum Engineering" in *McGraw-Hill Yearbook of Science and Technology*, 1964, McGraw-Hill Inc., New York, 1964.

Fisher, F. M. *Supply and Costs in the U.S. Petroleum Industry*, Johns Hopkins Press, Baltimore, Md., 1964.

Hobbs, Mel. "Advancements in Drilling Industry," *World Oil*, Feb. 15, 1965, pp. 67–76.

Lawrence, C. J. "New Robot is Deep-Sea Roughneck," *The Oil and Gas Journal*, July 15, 1963, pp. 108–116.

"Oil Makes Deepwater Plans," *The Oil and Gas Journal*, Dec. 28, 1964, pp. 81–85.

Scott, John. "Louisiana Offshore," *Petroleum Management*, July 1964, pp. 73–87.

Wage Structure: Crude Petroleum and Natural Gas Production, 1960. (BLS Report 181, March 1961).

de Nevers, Noel. "The Secondary Recovery of Petroleum," *Scientific American*, July 1965, pp. 35–42.

The Contract Construction Industry (SIC 15, 16, and 17)

Summary of Outlook Through 1970

Changes in technology in the construction industry are expected to continue to evolve slowly as more efficient production equipment, improvements in materials handling, increased prefabrication of building components, changes in architectural and engineering design, and new and improved construction materials are adopted. These technological changes are expected to continue to reduce unit labor requirements, but the effects on employment will be more than offset by the anticipated increases in growth in construction. Employment in skilled trades is expected to increase, but at uneven rates because of the varying effects of technology. Employment of laborers will probably increase only slightly over the 1965 level.

Outlook for Technology and Markets

Output of construction for the next 5 years is expected to rise at a faster rate than during the 1957 to 1964 period. The average annual increase in output as measured by value of new construction put in place (contract construction comprising about three-fourths of this total) in 1957–59 dollars was 5.4 percent during the 1947–57 period, and 2.4 percent during the 1957–64 period. When measured in current dollars, annual increases in output amounted to 9.4 percent and 4.2 percent, respectively.

Comparison of projections of the value of new construction in constant dollars from four major industry authorities shows an expected annual increase of about 3 to 5 percent between 1965 and 1970, an annual increase well above that for the 1957–64 period. Of the various types of construction, housing (which accounted for 40 percent of new construction in 1964), and highway construction probably will lead in this anticipated growth, reflecting an expected sharp rise in household formations and continued activity in the Interstate and Defense Highways program. Construction of plants and office buildings should increase. Government programs such as aid to urban transportation, aid to schools, and urban housing development contribute to the prospect for a high rate of growth through 1970.

Improvements in earthmoving machinery are resulting in increased efficiency. Continuing increases in the size, capacity, power, speed, and durability of earthmoving equipment, such as trucks, tractors, scrapers, and shovels, are resulting in the moving of many times the amount of material that was previously possible, and occasional reductions in operating labor. For example, scrapers now have speeds double those

Slip-form paving machine places a continuous concrete slab for a highway without use of side forms.

of a few years ago and two or three bowls, rather than one, each with 50 percent greater capacity. Earth augers that dig shafts and mechanical moles that bore tunnels are replacing much hand labor and a number of smaller machines in tunnel, sewer, and pipeline construction. A machine called the "octopus," essentially a tractor with a front-end loader and back hoe, replaces two or three pieces of equipment and their operators and is increasingly being used in a wide variety of small excavating jobs. Wheel excavators of the type used in strip mining, first introduced in construction in 1964, dig, convey, and load material continuously and, compared with conventional shovels, significantly increase speed of excavation for dams, reservoirs, and other extremely large earthmoving projects. At least three wheel excavators are used in the industry and prospects for more widespread application are favorable.

New portable construction equipment and hand tools are increasingly being introduced. This equipment, used in all types of building construction to reduce unit labor requirements, job costs, and completion time, includes power trowels, paint and plaster spraying guns, power nailing and stapling machines, and motorized wheelbarrows. The use of plaster spraying guns and pumping machines, for example, can reduce considerably the time required to apply plaster. This equipment doubles the amount of plaster a worker can apply in a day and enables a single plasterer to keep a larger number of workers busy to flatten and smooth the freshly sprayed plaster.

Advances in material-handling equipment continue to minimize handling problems and to decrease manpower requirements. Improvements in forklift trucks, conveyor-belt systems, motorized wheelbarrows, pneumatic pipe systems, and conventional cranes are facilitating the moving and handling of construction materials.

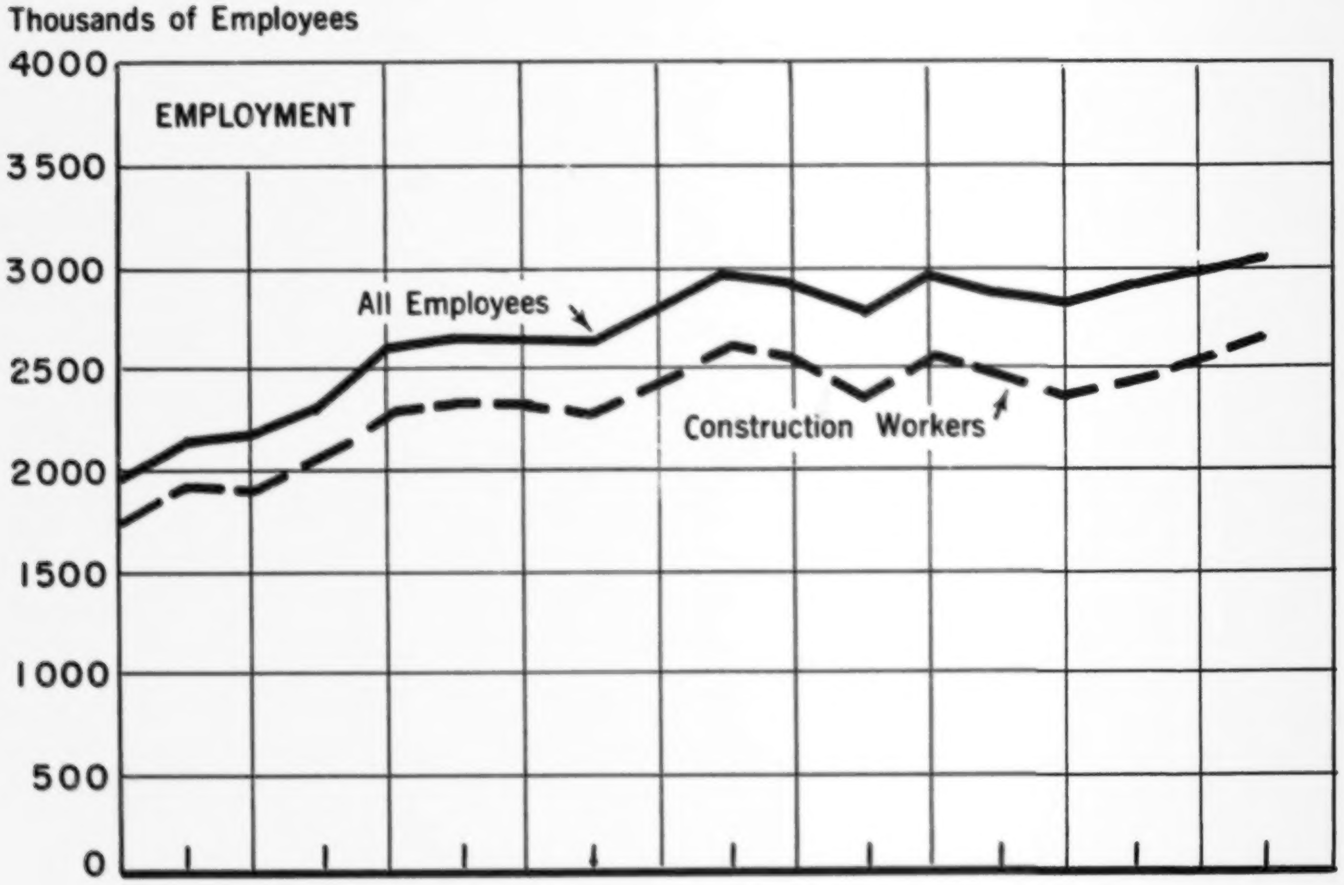
Another important development in material handling is the tower crane. Introduced into this country from Europe around 1959, tower cranes numbered an estimated 300 in 1963, have increased in use, and are expected to have widespread use in the future. Especially useful in the construction of tall buildings, tower cranes can be used to deliver material to any part of the top of a tall building—not just near the edge as do conventional crawler cranes—and to hoist material to greater heights. Because tower cranes can be used to deliver material where it is required, labor crews normally needed to shift material about when using conventional cranes are significantly reduced. For example, the use of a tower crane in the construction of one building enabled the reduction of crews of men working with concrete from 20 men to 5. In another job, one tower crane replaced two crawler cranes.

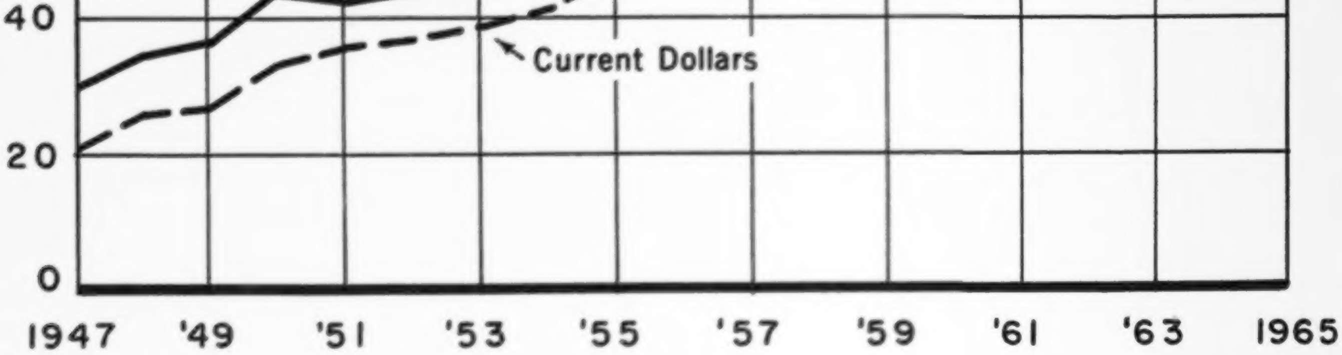
Significant advances continue to be made in paving. Major advances in both asphalt and concrete paving, which are improving the quality of highways and reducing unit labor requirements, construction costs, and completion time of construction jobs, include more portable and automatically controlled mixing plants; larger capacity and higher speed transit mix trucks; and more automatic, electronically controlled grading and paving machines.

Still another significant advance in concrete paving is the slip-form method which eliminates the fixed side forms used in conventional paving. Instead, forms are a part of the paving machine (slip-form paver) and slide forward with it leaving the concrete slab edges unsupported. This method of paving reduces costs by eliminating the need for crews to erect and remove forms. In addition, one slip-form paver can do the work of three conventional paving machines, thus reducing the number of machine operators and concrete finishers required. Accepted for production use in the last decade, 52 slip-form pavers are now used throughout the country. Some experts predict that in 10 years all concrete highways will be built by slip-form paving. Slip-forming techniques are also being increasingly applied to airport runway construction, to parking lot paving, and, more recently, to the construction of concrete walls of buildings.

Further progress in improving paving methods and techniques may result from standardization of highway construction specifications now being considered by the Bureau of Public Roads, the American Association of State High-

EMPLOYMENT AND VALUE OF NEW CONSTRUCTION IN THE CONTRACT CONSTRUCTION INDUSTRY





Sources: Employment, Bureau of Labor Statistics; value of new construction, Bureau of the Census.

way Officials, and other highway construction organizations.

Standardization of dimensions of construction materials and in design (modular coordination) decreases labor and material requirements. Since 1956, the U.S. Army Corps of Engineers has required modular coordination for all its projects and the Veterans Administration for its hospitals since 1960. This system, utilizing a standard unit of measurement of 4 inches and its multiples, also is gaining in use in commercial construction. Of the 878 products listed in the 1963 edition of *Building Products Register* which could be modular, 505 were available in modular sizes.

Modular coordination enables contractors to make more rapid and accurate estimates and affords reductions in on-site labor and materials costs. The Modular Building Standards Association claims that this system can result in a 7- to 10-percent saving in total construction costs. According to a contractor who has used both modular and nonmodular materials on similar projects, the savings in field labor are about 10 to 15 percent, overall labor savings from 1 to 6 percent, and there are additional savings in materials and time. For architects, the principles of modular coordination enable designing to be done faster and more accurately. For manufacturers, the standardized system of measurement could mean smaller inventories, reduced cataloging, and mass-production economies.

The trend toward prefabrication (preassembly of building components in manufacturing plants) will accelerate. According to the Home Manufacturers Association, annual production of prefabricated houses may more than double between 1964 and 1975. Prestressed concrete structural elements used for larger buildings and heavy construction, such as beams, roof and floor slabs, columns, and pilings, may increase by 150 percent between 1964 and 1970.

Among the major factors contributing to this advancing trend toward prefabrication are the significant savings possible in time, materials and on-site labor requirements, the higher degree of quality control possible in factories, and the greater opportunities for economies of large-scale production and mass-production techniques in construction. For example, a carpenter can install a complete prefabricated door (prehung in its frame with hardware attached) in about one-tenth to one-sixth the time usually required to hang a door in the conventional manner. According to one homebuilder, the walls and roof of a conventional wood-framed house which require about 500 man-hours to build on-site, can, with prefabricated components, be built (including off-site manufacture of components and on-site erection) in 200 man-hours or less.

Prefabrication of building components in factories makes possible significant reductions in labor required in construction (SIC 15, 16, and 17) while facilitating increases in employment in industries supplying construction materials.

New and improved materials continue to reduce significantly material and labor costs. By 1970, new products introduced during the decade of the 1960's are expected to account for a substantial portion of all building products sold in this country, reflecting the continuing advances in plastics, steel, concrete, paints, and other materials.

Plastics offer the advantage of ease of handling, ease of maintenance, and ability to be molded to extremely close tolerances and, thus, are expected to be widely used for an increasing number of applications such as piping, interior wall panels, exterior wall sections, insulation and moisture proofing, and roofing. Prestressed concrete products, expected to double in sales by 1970, offer considerable labor and other cost savings in many uses. Developments in structural design using high strength steel products can reduce the frame weight of buildings by as much as one-half in some instances, thereby resulting in significant material and labor cost savings. Aluminum siding, increasingly used for all types of buildings, can already be obtained with a factory finish guaranteed to last 30 years, reducing significantly manpower needs for exterior maintenance. Laminated wood beams, considered less expensive in some spans and more fire resistant than materials conventionally used, are being used increasingly in the construction of warehouses, retail stores, and light industrial and commercial buildings.

New paints require less on-site preparation, flow more smoothly, go on in fewer coats, and last longer, thus reducing costs and substantially reducing maintenance requirements. Adhesives are being more widely used to save time and reduce costs in floor bonding, exterior wall section fabrication, and in drywall erection. Because of its excellent fire-retardant qualities and low cost, gypsum board will probably increase in use for interior wall systems in commercial and residential buildings.

Improvements in design are continually being made. New concepts of architectural and engineering design make possible cost savings and productivity increases. More than a dozen new structural design concepts—all directed toward the economical utilization of space, materials, and the lowering of costs—have emerged since 1945. For example, plastic design, which enables an engineer to design beyond the elastic limit of steel, resulted in the construction of a warehouse for which 841 tons of steel were used, 141 tons (about 14 percent) less than the conventional design required. Space frame design, as used in thinshell construction, which utilizes form rather than the property of the materials to derive strength, will probably become more prevalent now that electronic computers are available to overcome the difficulty of manually performing the lengthy and time-consuming mathematical analysis required.

New systematic scheduling techniques are gaining acceptance among large contractors on complex projects. Techniques such as the Program Evaluation and Review Technique (PERT) and the Critical Path Method (CPM), particularly when used in conjunction with electronic computers, significantly improve management's capability to plan, schedule, coordinate, and monitor all steps involved in the completion of a complicated construction project. Basically, PERT and CPM are systems for charting the workflow of an entire construction project in detail. They provide a fast and flexible means of estimating the time required for each construction operation and completed project; of identifying potential bottlenecks; of coordinating interdependent operations; and of allocating and optimizing labor, materials, and equipment in order to reduce the total cost and performance time. These new scheduling techniques also are being used increasingly by large contractors to aid in multiproject planning, subcontracting, and preproposal planning.

Computers are being used increasingly for a variety of functions. Used mainly by large contractors engaged in large scale heavy construction and in commercial and industrial building, computers are being utilized to aid in design, production scheduling, subcontracting, and bid estimating. In bridge design, for example, computers are being used to help designers determine alternative designs for structures and the stresses that construction materials will convey. Currently, practically all State highway departments and the U.S. Bureau of Public Roads use computers as an aid in highway and bridge construction.

Manpower Trends and Adjustments

Employment may exceed its 1957–64 average annual rate of increase. Total employment increased from 2 million in 1947 to 2.9 million in 1957, an average annual rate of 4 percent. By 1964, employment had increased to 3.1 million at an average rate of 0.6 percent annually since 1957. Construction worker (production) employment followed the same pattern but at slightly lower levels during both periods. Growth in employment over the next 5 years may exceed that of the 1957–64 period because of an anticipated rise in construction activity.

	Average annual percent change
All employees	
1947–57	4.0
1957–64	.6
Construction workers	
1947–57	3.7
1957–64	.4
New construction put in place, value in 1957–59 dollars	
1947–57	5.4
1957–64	2.4
New construction put in place, value in current dollars	
1947–57	9.4
1957–64	4.3

However, employment will not grow as rapidly as construction volume because continued technological advances permit greater output per worker.

Extent of increase in employment will vary among skilled workers. Employment of concrete finishers, plumbers and pipefitters, roofers, structural-metal workers, lathers, and sheet-metal workers will probably grow faster than that of other skilled workers in construction because technological changes affecting their trades are not expected to offset the employment generated by the anticipated increase in volume of construction. The number of jobs for operating engineers, bricklayers, stonemasons, tile and marble setters, slaters, electricians, and plasterers is expected to increase at or about the average for all trades because the expected increase in the need for their skills will be offset to some extent by new equipment, new methods, and increasing use of prefabricated components. Employment of painters and carpenters is expected to increase less than that of most skilled workers mainly because of longer-lasting, easier-to-apply paints and off-site preparation of materials, which make possible reductions in construction employment while generating employment in the industries which produce the building materials.

Changes in technology will slow employment growth of construction laborers. Employment of laborers (including helpers and tenders), who numbered nearly 800,000 in 1964, is expected to grow only slightly because such functions as loading and unloading materials at the worksite, shoveling and grading earth, stacking and carrying materials, and other laboring tasks are generally being mechanized. For example, the use of pumps and conveyors instead of conventional wheelbarrows to move concrete, utilization of slip-form paving, and the substitution of tower cranes for conventional cranes tend to reduce laboring crews by one-half or more.

Increased winter activity may mitigate widely fluctuating employment. Due to the highly seasonal nature of construction work in most parts of the country, over one-third more construction workers are employed in the summer than in the winter. In 1964, for example, total employment ranged from 2.5 million in January to 3.4 million in July and August. Advances in construction techniques and materials, however, if widely adopted may tend to reduce these wide fluctuations in the future. One of the most important methods facilitating winter construction is the sheltering of the building site by a wood frame covered with sheet plastic.

Retraining programs promote new techniques. In 1964, there were over 340 training programs for journeymen plumbers and pipefitters resulting from the plan established by the plumbers' and pipefitters' union in 1955 to retrain older craftsmen in new techniques. Similar programs have been established by other building trade unions. Also, retraining for eligible unemployed construction workers is provided for under the Manpower and Development Training Act; for example, 200 unemployed members of a 3,600-man local of the Union of Operating Engineers have been trained in the operation of the latest construction equipment.

Multiplicity of diverse building codes creates problems in the introduction of new materials. Nonstandardized and static building codes throughout the country frequently do not provide for the use of new construction materials and methods. For example, use of some prefabricated components and plastic pipe is not permitted by codes in many localities. Such groups as urban and suburban developers, contractor and architect associations, and local governments are promoting the replacement of traditional codes, which specify the materials to be used, by codes under which performance requirements determine the material that can be used. One potential advantage of such a change is a substantial reduction in construction cost. A developer who built houses in two adjoining areas—one under a traditional code, the other under a performance code—claims that there was a substantial differential, favoring the performance code, on identical houses.

Selected References

Technological Developments

"The Big Change in Today's Prefab Market," *House and Home,* December 1964, pp. 69–77.

"The Building Industry," *The Role and Effect of Technology in the Nation's Economy* part 5. Hearings before a Subcommittee of the Select Committee on Small Business, U.S. Senate, 88th Cong., 1st sess., 1964, pp. 607–628.

"Construction Equipment," *Engineering News-Record,* Feb. 21, 1963, pp. 43–72.

Lokken, E. C. "What's New in Concrete Paving," *Civil Engineering,* March 1964, pp. 54–57.

"Modular Building, Is It Reducing Construction Costs?" *Constructor,* November 1963, pp. 25–27.

"The New Housing Industry: part 7, Technology's Promise and Performance," *House and Home,* November 1963, pp. 83–117.

"New Methods Gain for Walls, Framing, Thin Shells," *Engineering News-Record,* Jan. 23, 1964, pp. 54–56.

Ray, Gordon K. and Harold J. Halm. "Fifteen Years of Slip-Form Paving," *Journal of the American Concrete Institute,* February 1965, pp. 145–159.

Stern, E. L. "Productivity Gains Hold Down Rise in Road Building Costs," *Engineering News-Record,* Sept. 16, 1965, pp. 94–95.

"Useful Nuclear Explosives," *International Science and Technology,* February 1965, pp. 54–60.

Manpower Trends and Adjustments

Ball, Claiborne M. "Employment Effects of Construction Expenditures," *Monthly Labor Review,* February 1965, pp. 154–158.

Beinhauer, Frank H. "A Hard Look at Apprentice Training in Construction," *Constructor,* February 1965, pp. 38–40.

Clague, Ewan. "The Economics of the Construction Industry," *Constructor,* February 1965, pp. 22–24.

Kelly, Edward T. "New National Joint Board for Settlement of Jurisdictional Disputes," *Constructor,* March 1965, pp. 26–27.

Kheel, Theodore W. "How the 25-Hour Week Has Worked," *Jobs, Men, and Machines,* Charles Markham, editor, Frederick A. Praeger, 1964.

Manpower Needs in the Construction Industry, Building and Construction Trades Department, Executive Council, AFL–CIO, November 1963.

The Lumber and Wood Products Industry (SIC 24)

Summary of Outlook Through 1970

Output of the lumber and wood products industry will continue to rise slowly, with more rapid growth in plywood, veneer, particle board, and miscellaneous wood products. Because of continuing modernization of sawmills and planing mills and continuing competitive inroads on wood markets by other materials, employment may be somewhat lower by 1970 than in 1964. New opportunities are opening in the expanding sectors, especially in the South.

Outlook for Technology and Markets

Output of lumber and wood products will continue to expand gradually. The Federal Reserve Board's index of output increased at an annual rate of 0.8 percent between 1947 and 1957, but nearly three times faster between 1957 and 1964. Lumber production for 1970 is projected by the U.S. Forest Service at 34.6 billion board feet—about 4 percent above 1962; and for 1980, about 13 percent above 1962. Plywood production is projected to require 9 billion board feet of timber in 1970—about 52 percent above the amount required for the 1962 output; and for 1980, about 80 percent above the 1962 level.

Industry SIC 24 contains five 3-digit industries: SIC 241—logging camps and contractors; SIC 242—sawmills and planing mills; SIC 243—millwork, veneer, plywood, and prefabricated structures; SIC 244—wooden containers; SIC 249—miscellaneous wood products.

By 1970, per capita lumber consumption, according to U.S. Forest Service estimates, will be about 5 percent lower than in 1962; by 1980, about 10 percent lower. On the other hand, per capita consumption of veneer and plywood in 1970, compared to 1962, is expected to have increased by about 34 percent and by about 42 percent in 1980. (Of total lumber and plywood consumption, imports constituted 11 and 13 percent, respectively, in 1962.) Consumption of plywood is increasing because it covers a given area more rapidly than previously used materials.

New lumber products are being developed to enhance wood's competitive position. Lumber and laminated wood products, for example, are treated with fire-retarding chemicals allowing wood to compete more effectively with nonflammable materials in structural uses. Chemical treatment for wood preservation against insect and water damage also will aid wood's competitive position.

Overlays of plastic and resin impregnated paper on lumber may allow lower grades to be used for siding and other purposes requiring weather resistance or good paintable surfaces. Use of overlays reduces maintenance and may provide competitive cost advantages. The technique holds promise for future use, although limited at present to use on plywood.

Portable tower which replaces natural spar tree is used to assemble logs for shipment to the mill.

Some finishes on wood now are cured rapidly by irradiation and irradiation of wood impregnated with plastics has resulted in increases in some strength characteristics of as much as 100 percent. While the latter application for irradiation is not yet economically feasible, research aimed at lower costs continues.

New harvesting and transportation equipment and techniques are increasing logging efficiency. The natural spar tree (tree with top removed), used to assemble logs at a central loading point for shipment to the mill (high lead logging), is being replaced by a portable steel spar. About 350 of the latter were in use in 1964 and one official of a major producing firm expects them soon to replace the natural spar completely in that company's operations. Portable spars combine strength with mobility, can be rigged in 2 to 3 hours compared to the 2 to 3 days required for natural spar tree rigging, and handle more logs per hour.

Where yarding is not done by high lead methods (natural or portable spar), improved tractors assemble logs more quickly at central loading areas. New front end loaders and lifting equipment shorten time required to put these logs on trailers, and improved techniques, such as preloading of trailers, further increase the number of logs handled per hour.

For harvesting smaller diameter logs, two new machines eliminate much manual labor. The smaller "mechanical lumberjack" cuts pulp wood size trees up to 19 inches in diameter. Operated by one man, this machine cuts off the tree, felling always in the same direction, then picks it up, delimbs, and cuts it into 6 to 8-foot lengths which are caught and held in a sling which then opens to drop logs on the truck. Twenty-five of these machines are already in use for pulp wood operations in several southern locations. The larger machine, costing about $60,000, may be used to delimb and fell trees up to 24 inches in diameter and can produce hourly the daily output of an experienced logger equipped with a chain saw. Six of these machines are in use in the United States.

Experiments continue on use of helicopters and on balloon logging. Balloons may be feasible over difficult terrain where conventional high lead logging can not be used. Present experiments indicate that they would be economically competitive in many situations, although still under development. The helicopter is limited in possible use. Logs large enough to be used for lumber may be hauled by helicopter, but part of its lift capacity may not be used because two logs may be over the helicopter's capacity. This limit on lift capacity, combined with high operating costs, may restrict usefulness of helicopters in harvesting. One study indicates that to utilize carrying capacity fully, the hauling of small pulp logs would constitute the ideal helicopter use.

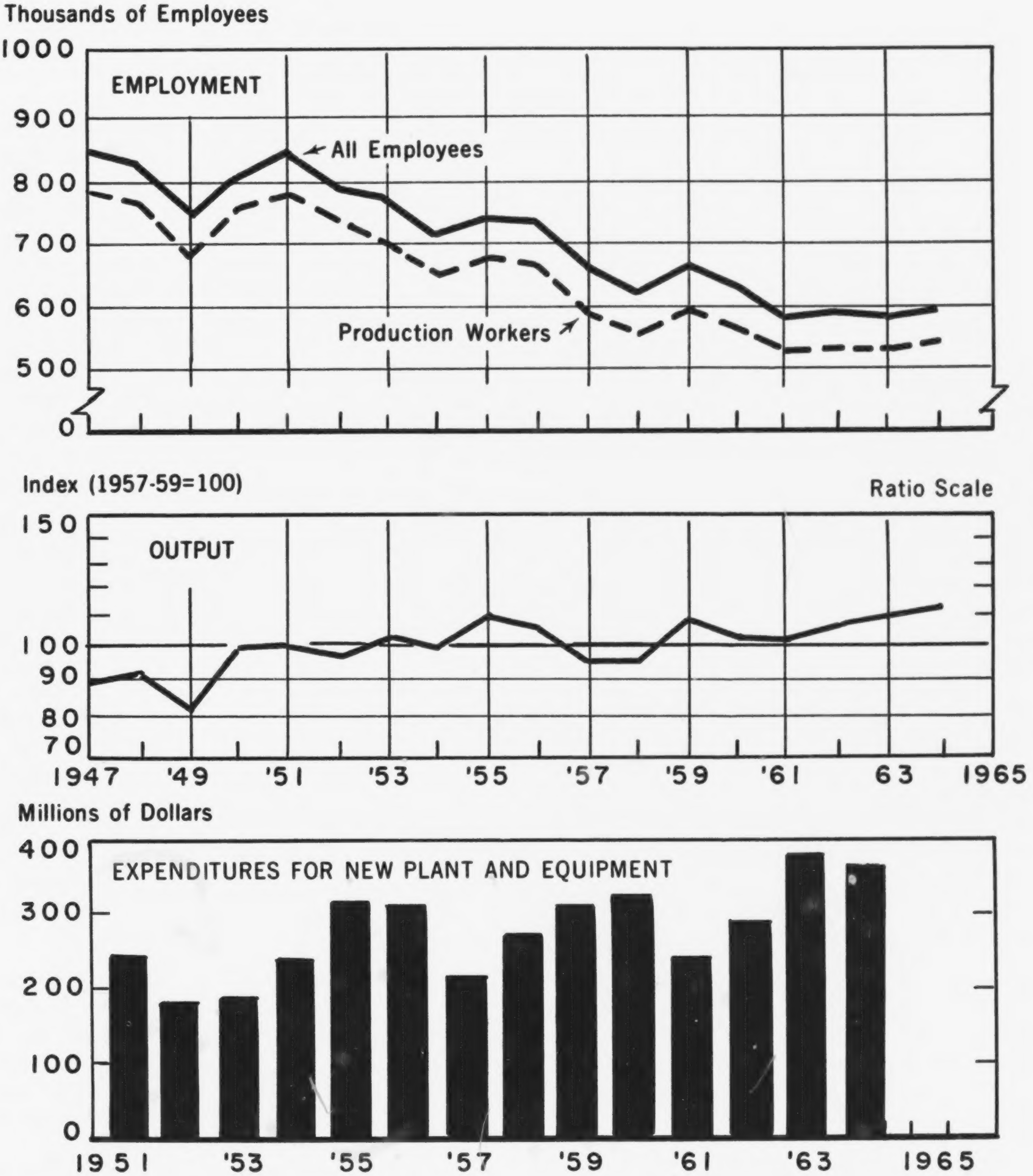
Sawmills are increasing their efficiency through use of better saws. High-speed gang saws, known as "scragmills," are being used extensively in the manufacture of studs from small logs. These mills use two or more circular saws mounted on the same mandrel to reduce the log to cants 4 inches thick. The cants are further reduced by a second set of saws to 2 x 4-inch studs. Scragmills substantially reduce the cost of producing studs. Some of the new saws used on secondary sawing equipment are thinner, thereby removing a smaller kerf (the amount of wood that is turned into sawdust) and are coated with carbide steel to extend their use between sharpening. These saws reduce work done by the skilled saw filer, although new skills and machinery are needed.

Another innovation in sawing—the Griffin Mill—uses a succession of circular saws, each saw taking a deeper cut than the preceding one. Lower power requirements and reduction in waste, because of the use of its sawdust particles suitable for pulping, are some advantages.

A newly introduced special chipper reduces small logs directly to cant size (sides squared) by chipping the sides, rather than sawing them, and saves labor in handling of slabs. Formerly, a log was reduced to cants by sawing off the sides, thus producing waste slabs later converted to chips.

Mechanical graders increase efficiency in grading of lumber. A recently developed electromechanical stress grader (machine grading is presently limited to lumber no greater than 2 inches in thickness) may result in more efficient use of structural lumber. When visual methods

EMPLOYMENT, OUTPUT, AND CAPITAL EXPENDITURES IN LUMBER AND WOOD PRODUCTS



Sources: Employment and output, Bureau of Labor Statistics; expenditures, Bureau of Census of stress grading are used, architects usually tend to specify larger than necessary material to assure required strength. The machine, by more precisely measuring stress values, will tend to eliminate such over-specification. Competition from steel and concrete may stimulate producers to avoid the excess safety factor allowances involved in visual grading.

Machine graded lumber, estimated at from 1 to 4 percent of the 1963 production, but gaining acceptance rapidly, is said to yield revenue of about $8 to $10 more per thousand board feet to the producer than the same lumber conventionally graded. Estimates on the time required for wide adoption of machine stress grading range from a few to more than ten years. Because such grading so far has limited application, and is generally supplemented by some visual grading on the same pieces, impact on the skilled visual grader may be minimized.

Improved gas jet and high frequency dryers (kilns) season lumber more quickly. Improved convection gas dryers speed up moisture removal as does a new, highly automatic, high frequency dryer capable of handling sawn lumber up to 6 inches in thickness. Both methods (the latter a European adaptation of the high frequency principle) reduce floor space requirements and accelerate operations, thereby reducing unit labor requirements.

Improved sorter systems reduce manual handling. Electronic devices with "memories" increase efficiency by allowing a console operator to cut and designate lumber for resawing or transferral by conveyors to saw, kiln, or storage areas without manual handling. Unskilled mill employees working as offbearers behind saws and as sorters are the principal occupations affected by mechanical handling.

Increased production per man indicates impact of advances in sawmill technology. In 1955, sawmills were planned so that 1,000 board feet were produced per man per shift. Many mills built since that time were planned to produce 3,000 to 4,000 board feet per man, and this level is still acceptable to some producers. However, newly planned and constructed mills are now designed to produce 10,000 board feet or more per man per shift.

Growth in number of plywood plants and changes in their geographic distribution will continue. According to the U.S. Department of Commerce, the number of softwood plywood plants increased from 96 in 1954 to 156 in 1963. Many new plants are in the capacity range of 90 million to 100 million square feet (3/8-inch basis), in contrast to older plants of approximately one-half that size.

Although concentrated on the West Coast, the industry is growing rapidly in the South. Following the first southern softwood plywood plant in 1964, 4 more were quickly established and 20 more are under construction or planned. A faster rate of expansion of capacity in the South is considered likely because new equipment now can process the small diameter Southern Pine, thereby enabling southern producers to take advantage of their lower transportation costs to eastern markets relative to Northwest producers of plywood. Ten years ago, plywood producers were considered efficient if they produced 100 square feet (3/8-inch basis) for each direct man-hour—now they are producing 250.

Rapid expansion of the particle board industry is expected to continue. Output of particle board plants has grown at an annual rate of about 16 percent from 1959 to 1964 and estimates are that 1965 output will be 26 percent above its 1964 level. In 1966, production is expected to be 42 percent above the 1965 level and sales are expected to reach $100 million. Particle board, made from wood chips, resins and waxes, by means of extrusion or pressing, is stable in composition and can be worked by standard wood processing techniques. It is used as underlayment, sheathing, and as core material for other products such as furniture and cabinets. In 1964, 53 plants were in operation with concentrations in the South and West.

Capital expenditures are increasing sharply. Capital expenditures for SIC 24 averaged about $279.5 million over the 1957–60 period. In 1963, they rose to $381 million—30 percent above 1962 and 19 percent above the previous high—about $320 million in 1960. They remained at a high level in 1964 ($369 million).

Research and development is conducted by a few major companies. National Science Foundation estimates R&D expenditures for the industry (including furniture, but excluding paper and pulp) at about $10 million each year, 1960–63. Much research is conducted by the U.S. Forest Service, some areas being growing, cutting and seasoning of wood, stress grading, chemical wood treatment, and use of chemicals derived from wood. Primary emphasis of private research is on increased salvage of former waste material, as well as fireproofing and code work.

Manpower Trends and Adjustments

Outlook is for some decline in employment. From 1947 to 1964, employment (all employees) in the lumber and wood products industry declined by 242,500 to 602,500, an annual rate of decline of 2.0 percent. However, 1964 employment was about 10,000 higher than in 1963. For the 1947–64 period, production workers declined by 252,800 to 530,200, an average annual rate of decline of 2.2 percent. Between 1957 and 1964, the annual rate of decline was 1.5 percent for production workers and 1.2 for all employees.

Average annual percent change	
All employees	
1947–57	–2.5
1957–64	–1.2
Production workers	
1947–57	–2.8
1957–64	–1.5
Output	
1947–57	.8
1957–64	2.3

Employment reduction in the logging camp and contractor classification, and in sawmills, comprising in 1964 over 56 percent of total employment, or 340,100, accounted for most of the decline. Wooden container manufacturing employment also decreased, from 43,200 in 1958 to 34,900 in 1964. Millwork employment has increased from 67,500 in 1958 to 69,500 in 1964.

Employment in miscellaneous wood products (encompassing wood preserving, production of pallets and particle board, and other manufactured products) has grown from 55,700 in 1958 to 70,100 in 1964. Veneer and plywood employment has increased from about 61,000 in 1958 to over 70,500 in 1964. Employment in these two industries (with 23 percent of lumber and wood products employment) is expected to continue increasing.

Occupational requirements are changing. As a percent of all workers, nonproduction workers rose from about 7 percent in 1947 to about 12 percent in 1963 and 1964. Mechanization is decreasing the physical labor required in such occupations as offbearer, feeder, turner, and loader. As a result of mechanization, declines also appear to be taking place in these specific occupations: blocksetter, stationary boiler fireman, car and truck loader, logdeckman, kiln drying stacker, air drying or storage stacker, offbearer for machine and headrigs, and watchman.

Another type of change is the increasing number of men operating larger capacity equipment. For example, while the number of trimmermen operating 2 and 3 saw machines seems to be declining, the number of men operating saws with 11 blades has increased.

New jobs are emerging as machine-sorter operator, tipple man, cutoff sawyer, and console operator who perform the operations previously handled by many more job categories such as catcher, turner, feeder, lumber straightener, dogger, trailer, and block setter. Workers, now stationed behind panel boards, control operations and actuate equipment by pressing buttons, pulling switches and pressing pedals. These new jobs require knowledge of lumber, and motor coordination and manual dexterity instead of the physical strength necessary for the occupations being gradually eliminated.

Labor and management, through collective bargaining, are beginning to give more attention to adjustments. In one large company having over 5,000 employees, union and management set up a joint committee in June 1963 to study problems generated by technological change. Another agreement provides local job protection by promoting local products in competition with those from outside the State, by means of an employer financed fund. One 1962 contract, covering 15,000 workers of several companies within a specified geographic area, provides that employees may take pension rights with them when moving from one employer to another.

Government funded training is being given at all skill levels. Over 2,000 persons in the lumber and wood products industry were trained in 1964, under the Area Redevelopment Act and the Manpower Development and Training Act: some at professional levels as forestry aids; some as skilled workers, such as grader, saw operator, finish patcher, and equipment (woods) operator. Semiskilled occupations for which workers were trained include lumber inspector, veneer grader, all around logger, sanding machine operator and variety saw operator. Also covered in this category are occupations in the plywood industry—veneer clipper and drier operator, lathe operator and glue spreader.

Selected References

"Automatic sorting system affects many mill operations," *Forest Industries*, April 1964, pp. 108–109.

Barnes, Sam, Associate Editor. "Wood Technology," *Machine Design*, July 30, 1964, pp. 78–85.

"Buschcombine puts meaning into engineered production," *Forest Industries*, September 1964, pp. 64–65.

"Extensive mechanization in new Southern plywood plant," *Forest Industries*, November 1964, pp. 84–87.

Freas, Alan D. U.S. Department of Agriculture, Forest Service, "Machine Grading of Lumber for Stiffness and Strength," Presented to Fifth FAO Conference on Wood Technology, Madison, Wis., 1963.

Guthrie, John A. and Armstrong, George R. *Western Forest Industry—An Economic Outlook*, The Johns Hopkins Press, 1961.

Hair, Dwight. *The Economic Importance of Timber in the United States*, Miscellaneous Publication 941, U.S. Department of Agriculture, Forest Service, 1963.

"Sending a plant back to school," *Business Week*, Nov. 28, 1964, pp. 65–66.

Sherman, Dean F. "The plywood industry—Where it is—Where it is going," *Forest Industries*, January 1964, pp. 35–39.

Industry Wage Survey, Southern Sawmills and Planing Mills, June 1962 (BLS Bulletin 1361, 1963).

Timber Trends in the United States, Forest Resource Report No. 17, U.S. Department of Agriculture, Forest Service, February 1965.

Wage Structure: West Coast Sawmilling, July 1959 (BLS Report 156, 1960).

Zivnuska, John A. "The Future of Wood in a Competitive Market," Paper presented to 1963 convention of the Society of American Foresters, at Longview, Wash.

The Furniture and Fixtures Manufacturing Industry (SIC 25)

Summary of Outlook Through 1970

Greater demand for furniture will result from increases in new family formation and disposable income. A more rapid diffusion of technological innovations, including multipurpose fabricating and materials-handling equipment, improvements in finishes and their application, and increasing use of plastics and metal, appears likely. The marketing advantages and prospective economies of modern mass production techniques are expected to accelerate the trend to larger company size.

A moderate growth in employment is expected to result from increased output despite technological advances promising greater efficiency in manufacturing operations.

Outlook for Technology and Markets

Higher rates of family growth and disposable incomes are expected to stimulate expansion in furniture production. The projected increase of approximately 18 percent in the family-forming age group (20 to 34) compared with a 6- to 8-percent total population growth between 1965 and 1970, should strengthen the market for residential housing and complementary furnishings. An increasing proportion of families owning homefurnishings, and rising disposable incomes will increase demand for furniture and fixtures. According to estimates by *Resources for the Future, Inc.*, private purchases of furniture and fixtures increased at an average annual rate of 2.9 percent between 1950 and 1960, and are projected to increase at an average of 4 percent annually between 1960 and 1970.

Significant technological changes include more efficient sanding. Multiple-stage belt sanders eliminate a number of manual handling steps required in conventional methods. One such sander is said by industry sources to produce with 2 operators in 8 hours, as much as 10 operators in equal time can produce on 2-drum and 6-belt sanders. In another application, widebelt sanders, in combination with coated abrasives, are replacing conventional planing in some areas of stock removal, turning out more uniform products and with fewer rejects.

About 8 to 10 percent of wood furniture production workers are engaged in sanding operations, and planer operatives less than 1 percent.

Improved woodworking machinery considerably lowers labor requirements. Industry sources estimate that about 85 percent of the shaping requirements of the average plant can be handled by a new automatic contour-profiler. This machine, operated by unskilled labor, produces shaped parts 2 to 5 times faster than the previous method of marking, bandsawing, and handshaping. The new profiler, with one operative, is said to pay for itself in about 2 years, while yielding a volume of production which required two operatives or more using the previous method.

Routers for producing cutouts in wood or for decorative grooving over flat and curved surfaces can now be programed (template-controlled) for automatic continuous routing of intricate patterns. (Programing is controlled by a unique cam and sensing system that is easy to set in the shop.) Unskilled operators need only to feed material to the machine; in some

Worker loads hydraulic-feed vertical gang borer equipped with hopper feed.

applications, even feeding is automatic. A more advanced design, being tested, can make three-dimension router cuts without a wood intermediate pattern, by following a simple black-on-white line drawing. Taken together, the router and profiler developments may affect as many as 2 percent of the wood furniture production workers.

Numerous advances have been made to reduce downtime and increase flexibility of machinery. New molders are fitted with cartridge-type spindle units which permit quick pattern changeover; spindle extensions for dado work and attachments for drilling, dovetailing, and sanding have been developed for automatic tenoners. Also, faster spindle operations and reduced maintenance are attained by the adoption of carbide-tipped blades, automatic lubrication, and sealed and nylon bearings.

Increased use of automatic equipment is lowering materials-handling requirements. Automatic stackers, conveyors, and hoppers are eliminating stockpiling of work in process and reducing the need for tailboys (unskilled assistants to convey materials between machines or processes). For flat stock, automatic panel-feeders are used to feed sanders, roller coaters, or conveyors leading to tenon machines; and automatic transfer (chain drive) units move stock between such shaping machines as tenoners and molders.

Assembly operations are faster. The use of pneumatic power clamps and assembly machines is speeding the assembly of frames, case ends, drawers, and chairs, while requiring fewer and less-skilled workers. One machine takes parts directly from a tenoner, feeds metal parts from hoppers, inserts these parts, drives pins or nails, and ejects a completed shelving onto a conveyor at a rate of 7 to 10 per minute, and only one operative is required to load the hoppers and pinners. Another machine takes panels, aligns and joins them perfectly square, drives staples to hold the assembly true while the glue dries, and permits the assembly of a kitchen cabinet by one man every 60 seconds.

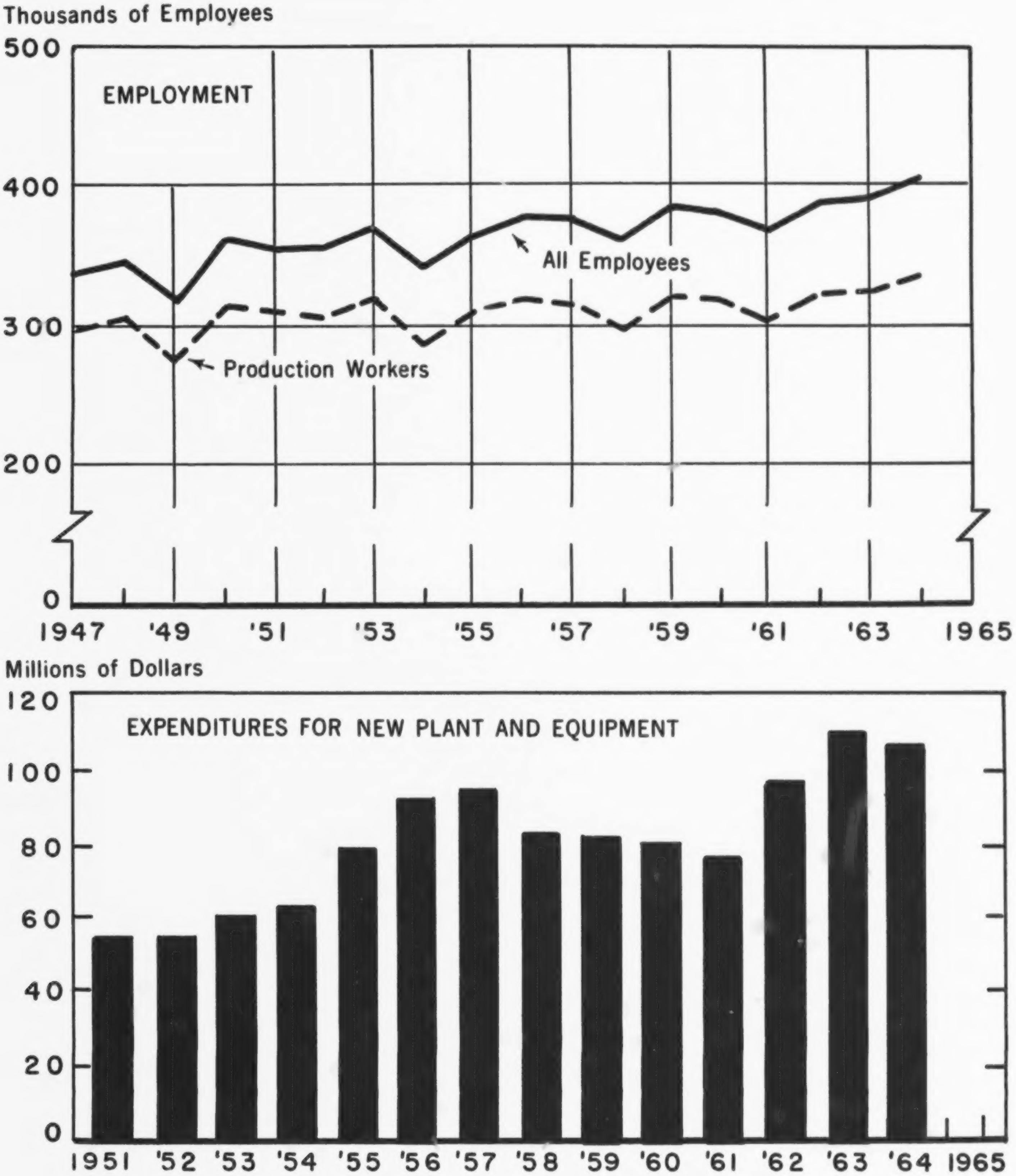
Faster upholstering and frame assembly with less operator fatigue are promoted significantly by improved power-driven fastening equipment such as nailers, staplers, tackers, and clippers. One new tacker enables an unskilled operator, with little practice, to drive tacks 5 to 8 times faster than the most experienced hand nailers, merely by pressing the nose of the tool against the work surface. Some fastening tools are built into jigs. For example, the new frame nailer clamps and fastens complete furniture frames in 2 seconds.

Electronic gluing is a potentially significant gluing technique. Gluing with radiofrequency (heating the whole wood mass uniformly and not just the surface) is a high-speed process beginning to be used increasingly in furniture manufacturing. However, its full economic advantages cannot be realized until there is further improvement in some other factors associated with good gluing techniques, such as resin formulations and control of wood moisture content.

Finishing materials are much improved. Air drying and baking time of many finishes steadily are being shortened to reduce process time cycles. Coatings are becoming more specialized and fitted precisely to their purpose. For instance, new synthetic materials (conversion lacquers and sealers) possess great toughness and will withstand most household reagents; finely ground pigments and new type thinners permit toners to penetrate wood more deeply and to extend the range of wood colors; some metal furniture finishes do not require a primer for adhesion, but have excellent resistance to abrasion. Bleaching systems are expensive, but economies are being created by new bleach solutions which eliminate the need for neutralizing washes and permit faster bleaching schedules.

Force-dry ovens significantly decrease the time required for finishing operations. High temperature, force drying of finishes by use of gas-fired convection or ceramic-type infrared ovens (some with individually controlled, multiple temperature zones to meet the needs of specialized finishing materials) drastically cuts finishing time and labor. Such high temperature ovens raise surface temperature to about 135°F. and permit sealers and lacquers to dry in 1 to 5 minutes instead of hours. One recently devel-

EMPLOYMENT AND CAPITAL EXPENDITURES IN THE FURNITURE AND FIXTURES INDUSTRY



Sources: Employment, Bureau of Labor Statistics; expenditures, Bureau of the Census.

oped force-dry system, using a special pallet conveyor, is said by industry experts to eliminate all manual handling through the finishing process.

The installation of this system at one modern plant resulted in 20 more cabinets being produced each hour with the help of three fewer men; total finishing and drying time was cut from 8 hours to less than 4 hours.

This new force-dry system requires the employment of especially alert foremen to insure steady, continued operation of the line at all stations. Slowdowns or breakdowns at any one point, that would lower but not disrupt production in the conventional system, are a serious interruption to production in the new system. Nevertheless, the industry is finding the new finishing method efficient. Two years after its introduction in 1962, approximately 90 such systems had been designed and installed.

Electrostatic spray painting systems are reducing labor and material costs. In these systems, spray guns operate automatically as the unfinished objects pass through critical points on a conveyor line. Paint savings of up to 50 percent are claimed over conventional manual air-spray methods; laborsavings depend upon the type of objects sprayed. The spray guns are actuated either by conveyor projections that trip over air valves, or by use of an electric (electronic) eye device. Irregularly shaped objects can now be sprayed by a new electrical mechanism which memorizes spray patterns. But the automatic spray system works best in mass production of uniform parts, especially when the parts have simple shapes.

Electrostatic finishing, previously practical only for metal pieces, has now been made possible for wood by a recently developed solvent which endows wood with electrical conductivity. However, questions remain as to permanency of adhesion, stability of the wood with aging, and applicability to other materials such as stain, filler, sealer, glaze, etc.

Plastics are being used increasingly in furniture. Examples of plastic materials in furniture making are plastic laminates; tough new plastics for shells and frames; and urethane or vinyl foams for cushioning that can be molded in contoured forms or foamed in place ("one-shot" molding), thus eliminating complexities of coil springs, fiber stuffing, and wood assembly. Greater freedom in styling, lighter weight, easier assembly, greater adaptability to mass production techniques, and longer life with little maintenance are some advantages of the new materials.

Use of plastics for furniture is increasingly important. In 1964, about 15 percent more vinyl and 12 percent more flexible urethane foam went into furniture upholstery than in 1963. An already sizable market continues to grow for plastics in school furniture, and plastics appear to be making significant breakthroughs in auditorium and stadium seating, where a great market potential is indicated. The Los Angeles Coliseum, for example, has ordered 46,000 blow-molded high density polyethylene seats, and has an additional 20,500 for delivery in 1966; in the 41,000-seat stadium at Houston, Tex., some 75,000 pounds of flexible urethane foam covered the seats.

Irradiated woods may be used in furniture production. Studies on production and commercial feasibility of radiation-processed composites of plastics and wood for furniture are being sponsored by the Atomic Energy Commission and a number of industrial firms. Tests indicate that such new composite materials can be made to retain the grain structure of natural wood while increasing resistance to scuffing, abrasion, warping, and damage by harmful chemical agents. A range of colors is made possible by combining dyes with the plastics material. Fabrication of the new material into products such as furniture requires no more than conventional woodworking machinery. The advantages of aesthetic appeal and ease of maintenance of irradiated woods may be offset by high costs of producing the material.

Use of steel, aluminum, and other metals facilitates mass production of furniture and widens design possibilities. The movement to suburban living and increased use of durable metal furniture by institutions are expected to bring increasing use of light-weight metals.

Adoption of modern technology is being facilitated by a trend to larger company size. The industry expects that the trend from small, family-held concerns will continue and that by 1975 there may be several furniture manufacturers in the $100 million annual sales class. It is believed that larger sized public corporations will afford the industry a stronger potential for modern mass-production techniques. Modern equipment designed for quantity runs is often not economically feasible for the low production volume of many small companies.

Investment for plant and equipment has been very high in the last 3 years. Expenditures for new plant and equipment were $96 million in 1962, $110 million in 1963 and $105.6 million in 1964, in all of these years exceeding the 1956 record of $92.4 million. Expanding demand should cause higher levels of investment to be maintained over the next few years.

Manpower Trends and Adjustments

A moderate increase in employment is expected. Employment increased at an average annual rate of 1.2 percent between 1957 and 1964, reaching a total of 406,000 in 1964. Anticipated output expansion is expected to sustain current employment growth rates. Employment will probably grow faster in the South, where the increase averaged 3.5 percent annually between 1957 and 1963.

	Average annual percent change
All employees	
1947–57	1.1
1957–64	1.2
Production workers	
1947–57	.6
1957–64	.9

Occupational structure is changing. Production worker jobs are expected to increase more slowly than total employment. Production workers as a percent of total employment declined from 88 percent in 1947 to 83 percent in 1964. Between 1950 and 1960, white-collar employment (according to Census data) increased from 17.1 to 19.4 percent of total employment. This group comprised managers, officials, proprietors, and professional, technical, clerical, and sales workers. Among blue-collar jobs, the number of mechanics and repairmen increased 43 percent to about 7,400; upholsterers showed a rise of only 1 percent to 19,000; the number of cabinetmakers declined sharply by 13 percent to 23,200. The number of laborers declined by 12.4 percent to 18,000. Plant operatives increased by 15 percent to 186,800, and continued to comprise approximately one-half of all employment in the industry.

Training periods for some jobs have been shortened by technological changes. Such traditional handicraft woodworking skills as shaping, joining, and finishing have been simplified by modern machinery; upholstery work is made less complicated by the use of precut, preformed, and stretch materials; painting has been mechanized by automatic spray and flow-coating techniques. Some machines, however, continue to rely for their operation on a high degree of skill. For example, the multi-spindle carving machines, while vastly improved, still depend completely on the skill of the operator, who must have considerable experience in order to turn out a reasonable quantity of good work.

Occupational training is being sponsored by the Federal Government. Manpower Development and Training Act funds are being provided for institutional and on-the-job training for skilled, semiskilled, and apprenticeship furniture manufacturing occupations such as upholstering, cabinetmaking, and finishing.

A number of collective bargaining agreements ease the impact of job displacement. Of 15 major agreements in 1963, covering 26,000 workers, three contracts for 4,600 workers provided severance pay and layoff benefits; one contract for about 1,100 workers provided supplementary unemployment benefits. Early retirement is provided in some pension programs.

Selected References

"Wide Belts Offer Automation, Accuracy, and Abrasive Planing." *Furniture Design and Manufacturing,* May 1964, pp. 56–61.

"Trends in Woodworking Machinery," *Western Furniture Manufacturing,* May 1964, pp. 20–21.

"Improved Assembly Techniques Cut Costs," *Furniture Manufacturer,* November 1961, pp. 18–22 ff.

"What Every Young Man Should Know About New Finishing Materials," *Furniture Design and Manufacturing,* June 1963, pp. 29–31 and 65–66.

"Automatic Electrostatic and Manual Steam Spraying," *Industrial Finishing,* November 1963, pp. 32–34 ff.

"Electrostatic Wood Finishing—A Reality At Last," *Furniture Design and Manufacturing,* April 1963, pp. 55–57.

"Cornwell's DeBurgh System Halves Finishing Time," *Furniture Design and Manufacturing,* August 1963, pp. 24–26 ff.

"Molded Frames and Upholstery," *Modern Plastics,* May 1961, pp. 176–177 ff.

"A Dedicated Search for Excellence," *Furniture Design and Manufacturing,* September 1963, pp. 20–33 ff.

"Biggest Western Furniture Plant Streamlines Operation," *Furniture Design and Manufacturing,* November 1963, pp. 24 ff.

"Furniture Makers Join Retailers, Other Home Lines in Look at Decade Ahead," *Wood and Wood Products,* September 1965, pp. 34, 36.

Industry Wage Survey—Wood Household Furniture, Except Upholstered, July 1962, (BLS Bulletin 1369, 1963). 58 pp.

The Glass Containers Industry (SIC 3221)

Summary of Outlook Through 1970

Output probably will continue to rise at the moderate rate of recent years. The industry is emphasizing product improvement. Major advances include lighter weight containers, a faster, less costly coloring process, new color shades to screen ultraviolet rays, and improved techniques of permanent decoration (labeling). Glass container making equipment already operates at a high degree of automaticity. Improved refractories are increasing product quality. Surface treatments which have decreased breakage facilitate the introduction of faster, more efficient equipment in packing and handling operations. The moderate rate of increase in employment and in output per man-hour are expected to be maintained.

Outlook for Technology and Markets

Output of containers has increased significantly since 1957. Output (based on BLS weighted index) increased at an average annual rate of 1.6 percent from 1947 to 1957; and at an annual rate of 3.5 percent from 1957 to 1963. *Resources For the Future, Inc.* estimates that the average annual rate of increase in shipments of glass containers over the period 1960–70 will range from 2.2 to 5 percent. (Shipments from 1960–64 increased at an average annual rate of 4.5 percent.)

The industry, through product innovation, is meeting competition of other types of containers. Many traditional markets for glass containers, such as milk and household products, have been penetrated by paper, metal, and blown plastic containers; however, these losses have been largely offset by large gains in glass containers for baby foods, spices, liquid shortenings, orange juice, instant coffee, and convenience foods.

In the beer market, which takes 18 percent of the industry's output, the industry is meeting competition from metal cans with the nonreturnable glass bottle. While the number of glass containers produced for the beer industry almost tripled between 1959 and 1964, metal can shipments increased about 17 percent. Most of the gain was realized from sales of the nonreturnable glass bottle. Cans took about 40 percent of the package beer market in 1959 and 41 percent in 1964, while nonreturnable bottles increased from 6 to 16 percent of total filling during the same years.

Container weight in pounds per gross, an important cost factor in manufacturing and shipping, is expected, according to industry sources, to fall from 82 pounds in 1960 to a possible low of 73–75 pounds in 1970.

Production facilities are being expanded and modernized. Batch house operations, which formerly required that three or four men spend 30 to 40 minutes to prepare a batch of raw materials for the furnace, now are handled by one man using automatic weighing devices in 5 to 10 minutes, thus increasing the output per man-hour for this operation by about 12 times.

Superior fusion cast refractories have a 4- to 5-year life compared with 12 to 16 months for the old type of refractory, and eliminate much shutdown time for repair and rebuilding.

Recently glass containers have become available in a wide variety of colors. A new coloring process greatly expedites and expands the production of containers of many different colors, the coloring (frit) being added to an individual forehearth as the glass moves from the furnace to the forming machines. Usually, the coloring materials are added to the furnace, making the entire output from all forehearths a single color glass. Change of color requires draining and flushing of a complete furnace, with accompanying production loss of several days time. Whereas production has been limited to 8 standard colors, a new coloring process will provide virtually an unlimited number of colors.

Additional colors to block ultraviolet rays have been developed. Because amber, the conventional color used to block ultraviolet rays, lacks merchandising appeal, new ultraviolet blocking greens, competitive in cost to standard greens, have been developed.

New surface treatments reducing scratches and breakage facilitate labeling and reduce handling costs. Three or more recently developed surface protecting treatments are already widely used. One water-soluble coating, made from vegetable stearic acid, protects the container surface from the time of manufacture until it is subjected to water. Another, a water-repellent coating made from silicones and organic acids, provides adequate surface protection but requires the development of new adhesives to overcome labeling difficulties. Polyethylene and other resins are used with success.

More permanent chemical surface treatments have been recently developed. These provide a high degree of scratch resistance (up to 100 pounds force to scratch the bottles) on both wet and dry bottles. The new treatments also provide good lubricity (less friction) and the overall results are stronger bottles and improved handling in the bottler's operation. One manufacturer ships such containers on automatically handled pallets holding 10,000 containers without dividers, and claims that this new glass surface can effect substantial savings in reduced handling costs.

Plastic coating of glass containers also protects against breakage and surface scratches during handling. Such a coating also facilitates labeling for wider eye appeal in off-the-shelf sales to consumers.

Improved surface treatments increase the speed of packing. Packing lines for glass containers operate at normal speeds of 100 to 300 containers a minute, and higher speeds are possible when certain pieces of the line are set in multiple rows. Equipment under development is expected to handle 1,000 containers a minute with no increase in breakage.

Improved decoration for permanent labeling is being developed to enhance marketing appeal. Decoration (label, printed matter, design) involves a wide variety of processes, such as gluing on paper, etching, cutting, engraving, silvering, enameling, and coloring, all of which advertise the contents and make glass containers attractive consumer packages.

For a single application (nonreturnable use), paper labels are the least expensive form of decoration, but new labels for each of 20 to 25 "round trips" make paper labels for returnable bottles more costly. Although not a new process, permanent labeling of the glass itself is being used by an increasing number of glass container manufacturers in place of a paper label. Permanent labeling may be accomplished by fusing an enamel onto the glass surface. Usually the application is by a screening process. A recently introduced technique in which the enamel label is applied cold is less costly than conventional, fired-on enameling.

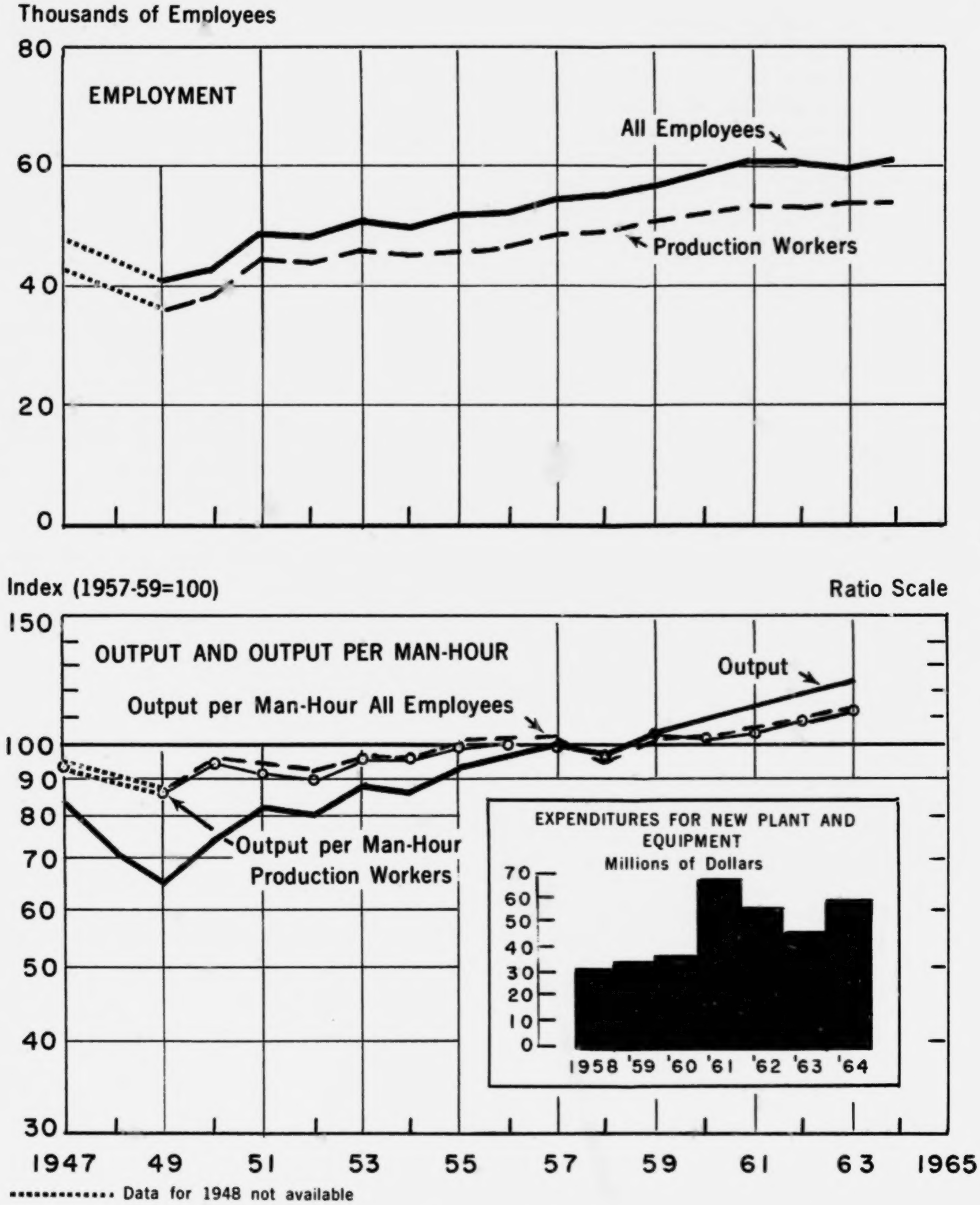
Electrostatic printing is in the experimental stage for permanent labeling of glass containers. Ceramic powders are electrostatically held where the impression is desired, and this decoration is fired in a conventional annealing oven or lehr. If this process is successful, initial application will be to returnable beverage containers, and with lower costs the process may become commercially feasible for permanent labeling of nonreturnable bottles.

An old process used for decorating glass dinnerware and ceramics with designs or pictures is sometimes used for permanent labeling of glass containers. The decoration is a ceramic transfer in which the label and other decoration are "glued" to the container. The application can be performed by unskilled labor.

New inspection techniques and full mechanization of bottle handling methods now are being employed. Until several years ago, inspection of the finished glass container was primarily by manual operation, with four or five girls visually inspecting only 90 to 100 containers per minute. Significant improvements in automatic inspection equipment and mechanization programs to provide single line inspection and automatic packing have reduced the need for manual inspection to the point where one girl, particularly in the case of longrun volume, now is able to inspect as many as 150 containers per minute.

Capital expenditures and research and development have shown substantial annual increases. Capital outlays increased from $31.2 million in 1958 to a total of $59.2 million in 1964. Six new plants have been built since 1963 and four more are planned. Some of the new plants represent

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN THE GLASS CONTAINERS INDUSTRY



Sources: Employment and expenditures, Bureau of the Census; output and output per man-hour, Bureau of Labor Statistics.

relocation of manufacturing facilities to centers of consumption. In 1963, there were 113 plants in the industry. Estimated annual expenditures for R&D increased from about $10 million in 1962 to $15 to $20 million in 1964.

Manpower Trends and Adjustments

Output per man-hour probably will rise at a moderate rate. Output per all employee man-hour and output per production worker man-hour increased at the same average annual rate, 0.5 percent during the 1947–57 period; the rate of increase for both groups rose to 1.8 percent during the 1957–63 period. It seems likely that the trends in output per man-hour for the more recent period will continue for the next few years.

	Average annual percent change
All employees	
1947–57	1.4
1957–64	1.6
Production workers	
1947–57	1.5
1957–64	1.5
Output	
1947–57	1.6
1957–63	3.5
Output per all-employee man-hour	
1947–57	.5
1957–63	1.8
Output per production worker man-hour	
1947–57	.5
1957–63	1.8

Employment is expected to continue increasing at a moderate rate. Total employment (Census) rose from 47,100 in 1947 to 54,300 in 1957 at the average annual rate of 1.4 percent a year. In 1964, total employment was 60,400, increasing at an annual rate of 1.6 percent a year since 1957. Production workers rose from 41,900 in 1947 to 48,400 in 1957 or 1.5 percent a year, and also rose 1.5 percent yearly after 1957 to 53,800 in 1964. Further output and plant expansion during the next 10 years is expected to more than offset the anticipated job loss on product handling, inspection, and packing lines, which will become more mechanized.

Portability of pensions has been provided under industrywide contract. Under a new contract, covering about 60 percent of the workers, an employee 40 years of age or older, who has had at least 15 years' service with a glass container manufacturer, may—if his services have been terminated because of a shutdown or curtailment due to automation—enter employment with another manufacturer participating in the contract and retain for pension purposes all accredited years of service with his original employer. The contract also provides that a covered member who is at least age 50 and has 15 years' service will receive his earned pension benefits at retirement age, regardless of cause of termination (other than disciplinary).

Problems arising out of technological change are under continuous labor-management study. The National Glass Container Labor-Management Committee, established in 1958, is composed of eight company representatives, the Glass Container Manufacturers Institute Director of Labor Relations, the International President, and the chief officers of the International Union. The committee was established to review problems under terms of the contract and discuss matters of mutual concern, prior to actual contract negotiation. Among subjects covered at periodic meetings of the committee are technological change and its effect on employment, the long-range outlook for glass containers, and employee problems due to plant relocation.

Selected References

Bowman, E. W. and J. H. Williams. "Annealing of Glass With the Automated Zonal Lehr," *National Glass Budget*, Feb. 6, 1965, pp. 16–19.

"Continuous Study of Critical Problems, The Glass Container Industry," in *Creative Collective Bargaining: Meeting Today's Challenges to Labor-Management Relations*. James J. Healy, editor. Prentice-Hall, Inc., 1965, pp. 229–243.

"Glass," *Chemical and Engineering News*, Nov. 16, 1964, pp. 80–96.

Griswold, Hugh T. and Charlton P. Whittier. "Innovation in Glass Containers," *Food Technology*, October 1962, pp. 78–81.

Grutzner, Charles. "The Glass Container Industry Is Expanding," *Industrial Bulletin*, New York State Department of Labor, April 1962, pp. 5–10.

Hackett, J. W. and H. A. Steigelman. "Surface Treatment of Glass," *Modern Packaging*, September 1961, pp. 146–148.

Industry Wage Survey, Pressed or Blown Glass and Glassware (BLS Bulletin 1423, May 1964).

"Light-Protective Glass," *Modern Packaging*, September 1960, pp. 109–111.

Meigh, Edward. "The Development of the Automatic Glass Bottle Machine," *Glass Technology*, February 1960, pp. 25–50.

Pilsbury, Richard C. "From R & D: Better Glass for Packagers," *Modern Packaging*, December 1964, pp. 104–107.

"Text of P & M Pact With Explanations," *GBBA Horizons*, March 1965, Glass Bottle Blowers Association, Philadelphia. 22 pp.

The Hydraulic Cement Industry (SIC 324)

Summary of Outlook Through 1970

Prospects for a faster rate of growth in output over the next few years depend primarily on construction activity. Output per man-hour will continue to increase at a faster rate as new and larger cement plants are put into production. Technological advances in the cement industry include more extensive and complex instrumentation and computer control, improvements in handling and shipping, and new techniques for reducing maintenance costs.

Employment will probably continue to decline. The jobs of production workers will involve, to an increasing extent, monitoring and maintenance of complex instruments. Occupational changes tend to reduce sharp distinctions between production and technical workers, and may create problems of labor-management relations.

Outlook for Technology and Markets

Cement production may rise faster in the next 5 years than in the past 5. Most of this increase will be due to an anticipated rise in construction activity. Cement production rose at a rate of 2.5 percent per year during 1957–63. According to industry experts, output may rise at an average of about 3 percent a year between 1963 and 1970, yielding about 445 million barrels of cement annually by 1970.

Capacity is expected to continue to exceed production. The cement industry operated at about 75 percent of capacity, or with an excess of over 100 million barrels per year, from 1960 to 1964. Production capacity was about 490 million barrels in 1964. Net planned expansion in 1965 is estimated at about 18 million barrels. While some excess capacity is the result of seasonal construction demands, a considerable part is in obsolete plants which will be under competitive pressures from new, more modern facilities. Although some obsolete plants may be shut down, excess capacity will probably continue to remain a major problem through 1970.

Plants are becoming larger. From 1950 to 1960, average plant capacity rose from 1.6 million barrels per year to 2.2 million barrels, and is expected to maintain its upward trend. For example, one midwestern firm has announced plans for a plant of 7 million barrels' capacity which will feature the largest kiln in the world —760 feet long and 25 feet in diameter. Size of working unit, in terms of product tonnage per unit, has about tripled in the past 10 years. In the past 5 years, kilns over 500 feet in length have become common; average kiln length grew from 188 feet in 1950 to 201 feet in 1954, and is still rising. Early in 1965, one new western plant replaced 13 smaller kilns with two new 530-foot kilns, increasing capacity by 50 percent and substantially reducing fuel costs and manpower requirements. In an eastern plant that was modernized in 1964, eight small wet grinding mills were replaced by one mill of greater capacity, five old kilns were replaced by a single large one, and two large finishing mills replaced six old grinding mills. The increased size of equipment has been a major factor in reducing unit labor requirements.

Instrumentation is becoming more extensive and complex. Meters, gages, indicators, scales, and similar instruments are being utilized increasingly in the production of cement to measure flow, temperature and pressure in kilns, density and weight of materials, and many other process variables. In recent years, the number has increased and quality of such measurement devices has improved. Centralized control of instrumentation, being used increasingly, reduces labor requirements significantly. Modern mills feature control panels with recording instruments monitored by a small staff.

Instruments used in many recently built plants provide sonic mill control for grinding. Microphones are tuned to pick up various sound levels from the grinding mill; feedback from microphones regulates the flow or amount of material to the mill, and thus the fineness of the product being ground. Closed-circuit TV systems for remote monitoring of key operations are becoming commonplace. X-ray spectrometers for raw materials and product analysis, and radiation absorption instruments for continuous weighing are also being introduced.

This equipment tends to reduce labor requirements, as well as maintain quality control and conserve raw materials and fuel. For example, the costs of operating an X-ray spectrometer, including maintenance, in one plant were considerably less than the costs of performing the same tests by conventional methods, if more than one shift was operated. The saving was achieved mainly because operation of the X-ray spectrometer required the full laboratory staff, including mix chemists, only on the day shift.

Since efficiency of cementmaking revolves around the close control of sintering in rotary kilns, instrumentation of kilns is particularly highly developed. As kilns become larger, control of speed, temperature, fuel and other variables becomes more critical and the accuracy of instrument measurements more important. Automatic lubrication, longer life refractories, and dust control and recovery equipment which improves draft and minimizes heat loss, also increase kiln efficiency.

Prospects are favorable for more extensive use of computers. Late in 1962, computers were either installed or being installed at 13 plants. In 1963, a California plant became the first to feature complete on-line, closed-loop computer control; the computer automatically and continuously calculates raw mix, controls kiln burning, and prepares periodic reports for management. Four other plants now use computers in process control.

Benefits derived from computer control include more uniform product quality, fuller utilization of equipment capacity, reduced fuel costs, greater production with the same labor force, and increased life of kiln lining. No control system is designed today without consideration and provision for future computer control. Within 5 to 10 years, most new cement plants will incorporate a computer as part of the basic process system.

Investment in controls is increasing. Investment for controls (instruments and computers) in cement plants has climbed from an average of 3 percent to around 5 percent of annual capital investment in the past few years, and may rise to 8 percent by 1970. Since units of production are becoming larger and costlier, an increase in this ratio is limited. However, larger, more complex units create the multiple relationships which make controls desirable and economical.

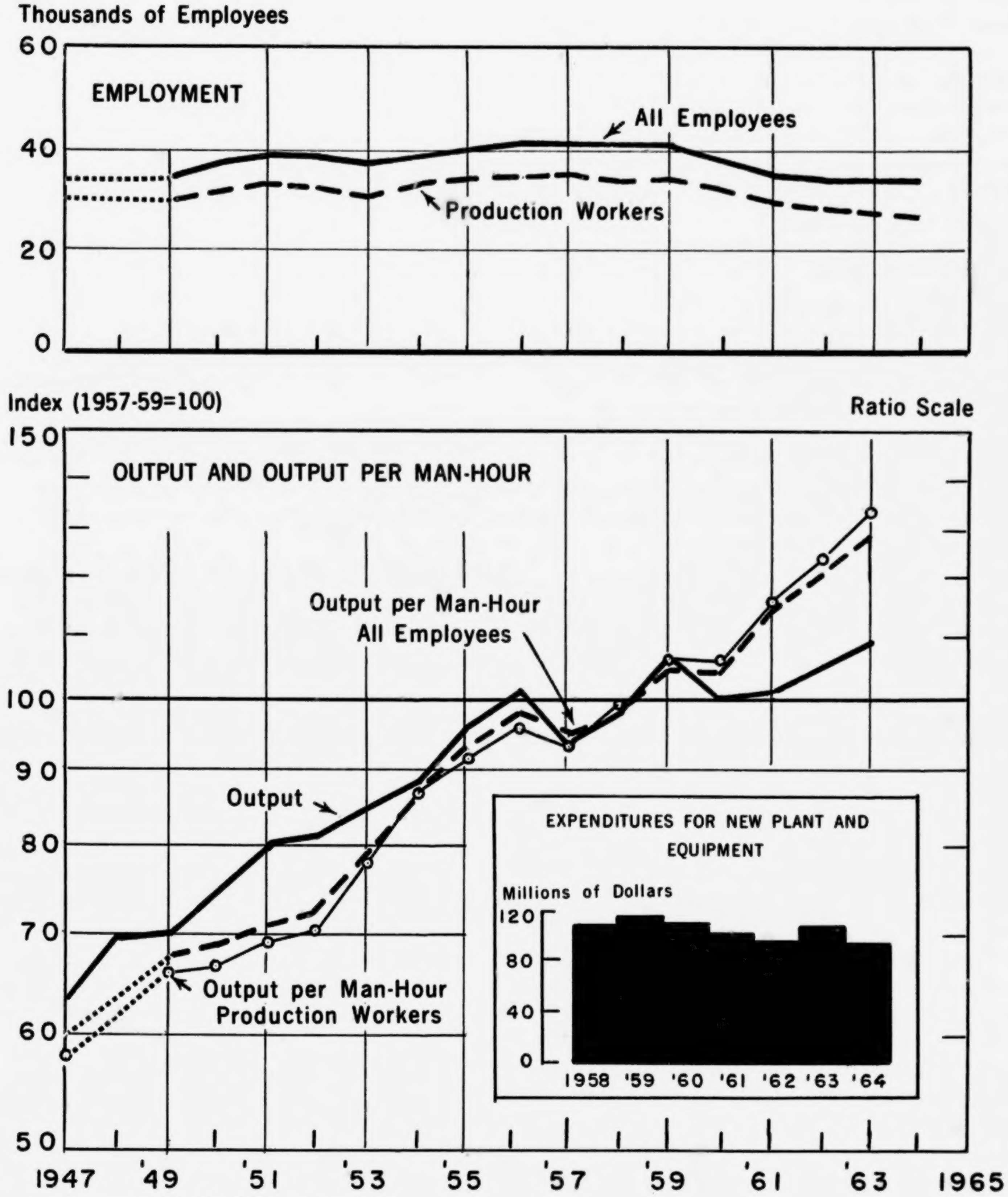
Many changes in distribution are underway. Shipments by truck continue to gain steadily over rail shipments. In 1961, trucks became the dominant method of shipping and in 1964 accounted for about 66 percent of all portland cement shipments. Plants located near waterways are using barges increasingly for shipments to distribution terminals.

Bulk movements continue to increase over other methods. Over 87 percent of portland cement was shipped by bulk in 1964, a record high; the rest was shipped mainly in paper bags. In 1958, 79 percent of shipments were made in bulk. Bulk shipments were made possible by pneumatic handling and require less manual labor for loading and unloading.

New distribution terminals afford marketing advantages. These facilities, where cement is stored, enable the large capacity plants to extend their marketing areas beyond the tradi-

Operator and trouble shooter monitor automatic controls and computer which control cement plant operations.

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN HYDRAULIC CEMENT



.... Data for 1948 not available

Sources: Employment and expenditures, Bureau of the Census; output and output per man-hour, Bureau of Labor Statistics.

tional 200 to 300 mile radius of the plant. At the end of 1964, an estimated 200 distribution terminals were in operation, virtually all built since 1960. Since trucking, with fewer barrels of cement per load, placed a premium on quick and frequent service, plants located some distance from the market area found themselves less competitive than they were under the rail system of delivery. Activity in building these facilities has apparently slowed down.

Plant and equipment expenditures will probably remain near the average level of the past 7 years. From 1958 to 1964, expenditures for plant and equipment fluctuated between a high of $119 million in 1959 and a low of $94 million in 1964, averaging $107 million a year. Late in 1964, at least 12 companies reported that they would be building new plants or completely remodeling old, obsolete ones in the next few years. Some companies also are expanding or building new research facilities.

Research and development on new types of cement and concrete may lead to increased demand. To take up the slack between capacity and consumption, the industry is undertaking research to extend the uses of cement through company and trade association programs. Demand for cement is also enhanced by research done by producers of concrete products. Thus, development of prestressed concrete, soil-cement paving, thin-shell roofs, expansive concrete, lightweight concretes, white cement, and numerous precast concrete products is creating a great demand for cement.

Progress continues in reducing fuel and power requirements. Fifteen years ago, an average dry process plant used about 1 million B.t.u. per barrel of cement, and the average wet process plant used about 1.4 million B.t.u. per barrel. Plants averaged about 0.9 and 1.0 million B.t.u. per barrel, respectively, in 1963. Lower fuel requirements reflect the increasing size and efficiency of kilns. New, larger machinery, on the other hand, require added power. Nevertheless, average kilowatt-hours per barrel of cement have been reduced from 21 to 23 in 1950 to 18 to 20 in 1963. Coal is still the main type of fuel, with 59 plants using it as their sole source of kiln heat in 1964; 52 other plants used coal with gas or oil.

Manpower Trends and Adjustments

Output per man-hour will probably continue to rise rapidly. Output per all-employee man-hour increased at an average annual rate of 5.3 percent between 1957 and 1963; the annual rate between 1947 and 1957 was 4.7 percent. The growth rate of output per production worker man-hour was slightly higher during both periods. A higher rate of capacity utilization and the opening of large, technically up-to-date plants is expected to result in a higher rate of growth over the next 5 years, compared with the 1957–63 period.

Employment is expected to continue to decline. The outlook is for a continuing decline in employment, despite an anticipated faster growth in output, because greater productivity is expected. However, the rate of decline will probably be slower than during 1957–64. Total employment (Census data) in 1957 was 41,600, the postwar peak, which was well above the 1947 level of 35,700. By 1964, employment declined to about 34,500, at a rate of 2.6 percent a year since 1957.

	Average annual percent change
All employees	
1947–57	1.5
1957–64	−2.6
Production workers	
1947–57	1.6
1957–64	−3.6
Output	
1947–57	4.0
1957–63	2.5
Output per all-employee man-hour	
1947–57	4.7
1957–63	5.3
Output per production worker man-hour	
1947–57	4.9
1957–63	6.0

Production workers are declining relatively faster than total employment. Between 1957 and 1964, production worker employment declined 1 percent a year faster than total employment. The ratio of production workers to total employment declined from 86 percent in 1947 to 81 percent in 1964, largely because of plant mechanization. Part of this decline also reflected slightly lower capacity utilization. As capacity is more fully utilized, the decline in the ratio may be slowed, since employment in administrative, technical, clerical, and sales work may not increase as much as in production worker jobs.

New jobs involving monitoring and maintenance of instruments appear in automated plants. The console room technician, one of the key new jobs, consolidates the work previously done by five separate people in the conventional type of cement plant: kilnburner, finish operator, raw grinder, crusher operator, and blending tank operator. Normally, four technicians are employed in a plant and work around-the-clock shifts in the console room. They monitor panels of the console, observe the crusher and kiln by means of closed-circuit television, operate the automatic control board, and adjust, start, and stop most plant operations. Frequently they must make independent judgment as to the corrective action needed when trouble is indicated.

Another key job is that of instrumentation technician. His job, along with his supervisor, the instrumentation engineer, is to oversee the electrical wiring of the console room and its equipment. His work is more like that of a highly skilled maintenance worker than that of an electrical technician. Console and instrumentation technicians normally receive intensive formal training before assuming their duties, and then on-the-job training for several months.

Maintenance will receive greater attention. Maintenance accounts for a large share of total production man-hours. One industry source estimates that maintenance now requires at least 60 percent of production man-hours in milling. In the larger plants, maintenance absorbs a relatively large share of costs because of the need to keep large units operating full-time during peak demand periods. Cement producers are requiring automatic built-in machinery maintenance, such as automatic lubrication and simplicity of design in order to reduce maintenance time and costs.

Questions have arisen over including technical employees in the bargaining unit at an automated cement plant. The National Labor Relations Board decided in 1962 that some technical employees in a highly automated cement plant should be included in a production unit. A Federal court opinion upholding the NLRB's decision asserted that "Automation must necessarily bring to industry a new concept of operational and maintenance functions . . . . So, too, automation may bring to the technician and operational employee a much closer relationship and community of interest."

Workers are seeking provisions for greater job security. Efforts are being intensified to improve job security through expansion of the basic supplemental unemployment benefit plan, higher compensation for overtime work, improved pensions, and higher severance pay. Major collective bargaining agreements in 1965, affecting a majority of cement workers, included provisions guaranteeing to workers 95 percent of their previous wage rates on transfer to lower rated jobs necessitated by introduction of new equipment. Other job security measures included substantial improvements in SUB plans; early retirement for employees affected by plant shutdowns or permanent layoff; and a job security clause stating that employees would not be terminated as a result of mechanization, automation, change in production methods, installation of new or larger equipment, the combining of jobs, or the elimination of jobs.

Selected References

Technological Developments

Barton, William R. "Cement," *Minerals Facts and Problems, 1965 Edition*, Bulletin 630, Bureau of Mines.

——. "Cement," *Minerals Yearbook*, 1964, Vol. 1, Bureau of Mines, 1965.

Bergstrom, John H. "Cement Plants of the Sixties," *Rock Products Mining and Processing*, May 1964, pp. 77–88.

Blau, Robert E. "Cement Industry Weathervanes," *Rock Products*, May 1963, pp. 80–85.

"Cement Strives to Pour the Proper Profit Mix," *Business Week*, July 17, 1965, pp. 144–146 ff.

"Economics of Cement Production," *Construction Review*, Business and Defense Services Administration, Dec. 1964, pp. 4–7.

Guccione, Eugene. "New Developments in Cement Making," *Chemical Engineering*, Nov. 23, 1964, pp. 112–114.

Prokorney, E. J. "Computer Process Automation—Current Practices and Future Possibilities in the Cement Field," *Minerals Processing*, August 1963, pp. 20–22.

"Review of the Cement Industry," *Pit and Quarry*, February 1965, pp. 107–111 and 144.

Rock Products, (Annual Cement Issue), May 1965, 208 pp.

Trauffer, Walter E. "Cement," *Pit and Quarry*, (Annual Forecast), January 1965, pp. 86–97 and 110.

Manpower Trends and Adjustments

1965 Collective Bargaining Agreement, Ideal Cement Company and United Cement, Lime and Gypsum Workers International Union, May 1965, (mimeographed), 21 pp.

Current Wage Developments, No. 211, Bureau of Labor Statistics, July 1, 1965, pp. 4–5 and 20–21.

Decisions of National Labor Relations Board, V. 137 Supplemental Decision and Direction of Election, Dewey Portland Cement Company and United Cement, Lime and Gypsum Workers International Union, Case No. 16–RC–2899, June 27, 1962, pp. 944–950.

Hastings, Norman. "Cement Plant Instrument Maintenance Experience," *Minerals Processing*, February 1964, pp. 30–33.

The Concrete, Gypsum, and Plaster Products Industry (SIC 327)

Summary of Outlook Through 1970

Growth of output is expected to continue at the present high rate if construction activity continues to increase. Technological advances, featuring new products, prefabricated products (particularly prestressed concrete), improved methods of concrete curing, more efficient production equipment, and instrumentation, continue to advance productivity. Employment is expected to rise because of increasing demand. Unskilled manual occupations may decline while those requiring machine-instrument operating and maintenance skills may increase.

Outlook for Technology and Markets

Production is expected to continue to increase at a high rate. According to the Federal Reserve Board index, output increased at an average annual rate of 4.9 percent between 1957 and 1964, substantially lower than the 8.2-percent rate for the period 1947–57. If construction activity continues to expand, production will probably continue to increase near present rates during the next 5 years.

Prestressed concrete and other prefabricated concrete and gypsum products are expected to increase in importance. Prestressed concrete (concrete reinforced with tensioned steel) is replacing steel, lumber, and ordinary reinforced concrete in many structural building applications. When used instead of structural steel, prestressed concrete containing 1 ton of high-tensile steel can replace as much as 7 tons of ordinary structural steel. Standardization of prestressed concrete sections produced on a mass production basis makes the material economical and adaptable for bridge and building construction. Large-span and multistory buildings are considered by some experts to offer the best markets for prestressed concrete during the next decade. Prestressed units such as floor and roof slabs, beams, columns, and wall panels will probably be made available as standard stock items in a variety of sizes, similar to those of lumber and steel products, in the foreseeable future. Sales of prestressed concrete have increased since its introduction in 1950 to over $200 million annually in 1964. By 1970, sales are expected to more than double.

Other prefabricated concrete products such as culvert and sewer pipe, lightweight blocks, block panels, and decorative components are also expected to grow in importance. Moreover, growth in the use of prefabricated gypsum products is expected to continue. About 56 percent of gypsum used or sold in 1964 was in the form of prefabricated building products, compared with 51 percent in 1958. However, unless new uses or products in the prefabricated field can be developed for gypsum, increased competition from alternative materials such as plywood, aluminum, and plastics could restrain future growth.

Changes in steel technology increase markets for lime. The rapid growth of basic oxygen converter steelmaking has been a major factor in the improved demand for lime. Oxygen converters use about 125 pounds of lime per ton as fluxing, about five times as much as in open-hearth steel processing. Increased use of oxygen converters to produce high carbon steel will further increase demand for lime used as a flux. Some 1970 estimates project total consumption of lime by the steel industry, the largest single consumer, at about 4 million tons, 80 percent more than the 1964 level. Another important growing market is soil stabilization for highway construction where use of lime should exceed a million tons by 1970.

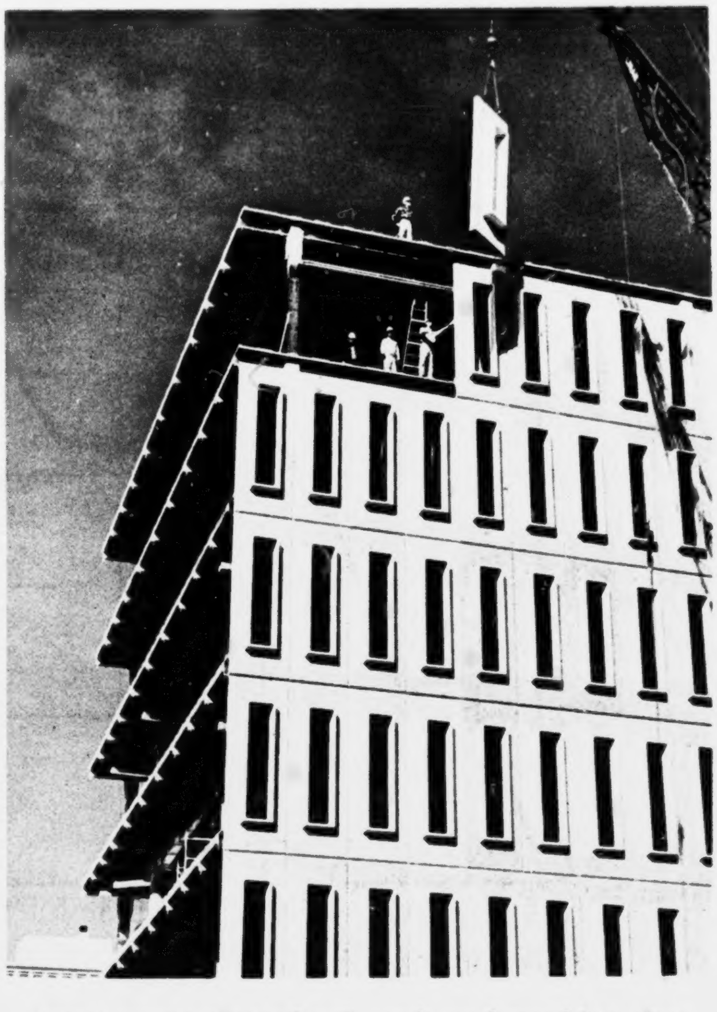
Use of ready-mixed concrete will continue to reduce on-site construction labor requirements. Use of ready-mixed concrete, replacing concrete prepared at the construction site, continues to shift labor requirements from on-site construction to ready-mix plants and increases opportunities for economies of large-scale production techniques. In 1964, the output of ready-mixed concrete amounted to nearly 160 million cubic yards, or more than triple the output in 1950. Advances in instrument control of the batching plant continue to improve product quality, and larger capacity, higher speed transit-mix trucks are providing more economical delivery.

Continued product improvements enhance future growth of markets for concrete. Expansive concrete, for example, which was introduced on a developmental basis in 1964, expands just enough to offset natural shrinkage, thus overcoming to a large extent the tendency of ordinary concrete to crack when drying. Also, in contrast with ordinary concrete, the new concrete makes possible the pouring of large areas of concrete without joints, is completely waterproof, and will not crack when properly reinforced. Expansive concrete reportedly has longer life and greater load strength than ordinary concrete. Although the new concrete is relatively more expensive than regular concrete, various users report that its improved qualities more than offset the additional cost. Research is underway to improve further the properties of expansive concrete and to expand its applications.

Concrete made with lightweight materials (such as expanded clay, shale, slag and fly ash) is being used on an increasingly wider scale. Significant advantages of concrete made with lightweight materials are weight reduction of about one-third without significant loss of strength and improved insulation and accoustical properties. Labor requirements for handling are generally lower than for the heavier regular concrete.

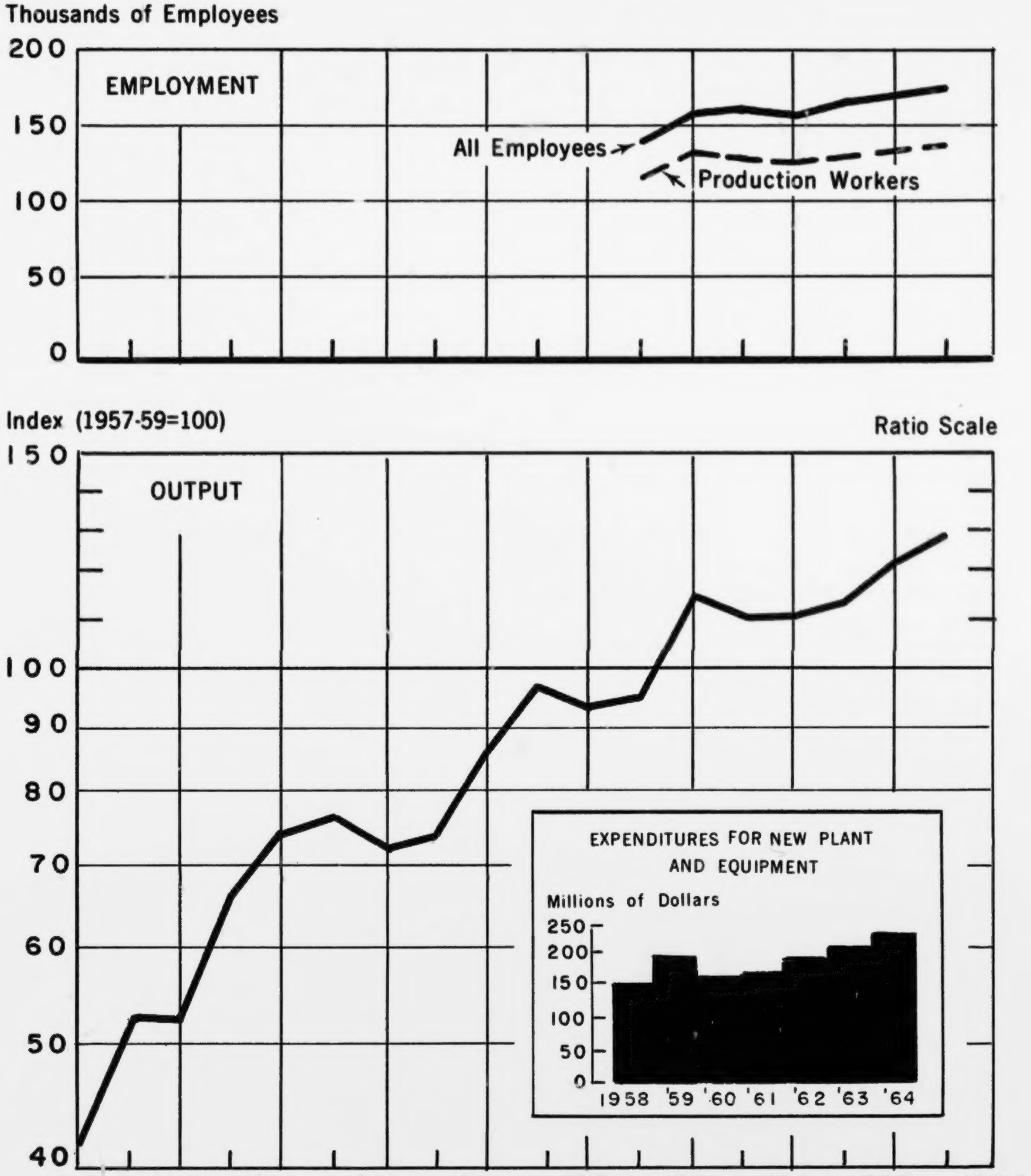
Applications of epoxy materials are being developed that may open up possibilities for greater use of concrete products. Epoxy materials replace mortar for joining prefabricated concrete units. Because of the significantly increased strength of the bond, some experts speculate that in the future it may be possible to build complete structures by gluing precast concrete units together. Used as a coating, epoxies may greatly expand the use of concrete products where waterproof and chemical-resistant properties are essential, as in the use of concrete pipe for disposal of industrial wastes. It can also be used to provide concrete surfaces, such as highways and floors, with improved skid-resistant and wearing properties.

Improved methods of concrete curing (speeding up the hardening process) continue to win wider acceptance. Compared to the traditional method of moist curing, steam curing reduces the time required for curing concrete products from several days to about 24 hours, and minimizes shrinkage, thereby reducing cement requirements and increasing strength of concrete products. Curing in pressurized chambers (autoclaves), a further development of steam curing, is just beginning to win wide acceptance in the industry. Easily adaptable to mechanization of materials handling, autoclave curing further reduces curing time and increases product quality. Since the curing cycle is significantly speeded up, orders can be filled more rapidly—reducing the need for maintaining large, space consuming inventories. With continuing emphasis on better quality concrete products, curing by autoclave is expected to be used more widely in the future.



Precast concrete structural wall panels are lowered into place.

EMPLOYMENT, OUTPUT, AND CAPITAL EXPENDITURES IN CONCRETE, GYPSUM, AND PLASTER PRODUCTS



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board; expenditures, Bureau of the Census.

New systems of steam generation for autoclave curing will probably gain wider acceptance. Recently developed systems eliminate the conventional use of a high pressure steam boiler, and thus remove the need for a licensed fireman or engineer. For example, curing costs have been reduced as much as 46 percent because of manpower savings achieved through the use of the Petrotherm method. Using this method, steam is produced by circulating hot oil through pipe submerged in water in the floor of the autoclave. In addition, these new systems produce concrete products of more uniform quality by completely saturating the curing chamber with steam, eliminate the need of boiler-housing, and reduce space requirements.

Greater use of improved equipment in concrete block plants is expected to reduce labor requirements. A trade association sample survey of 86 concrete block plants showed, in 1962, that 55 percent of the plants surveyed were mechanized in at least one of the four major steps of production—an increase of 16 percent over 1961. In recent years, about 7 or 8 percent of the 1,800 block plants have mechanized annually either raw materials handling, proportioning of raw materials (batching), mixing of concrete, or block handling. By 1970, it is predicted that about 80 percent of all block plants will be mechanized in at least one of these four major steps of production. Use of new block forming machines and mechanization of loading, unloading, and stacking—operations usually performed manually—can substantially increase output per man-hour; in some cases, as much as 100 percent.

Instrumentation is expanding in use. Gages, scales, meters, indicators, and similar instruments are being used increasingly to control weighing of raw materials, measurement of flow, temperature control, and other process variables. In advanced plants, automatic conveying and storing of raw materials are monitored by closed-circuit television. Radio dispatching of ready-mixed concrete trucks is nearly a standard procedure. Automatic recording of weights of raw materials, of batching time, and of delivery truck identification by digital, graphic, or photographic recorders is replacing manual data logging in ready-mix operations.

Centralized control of instruments—essentially a panel localizing all indicating, monitoring, and adjusting instruments—is being used more widely in the production of ready-mixed concrete, gypsum wallboard, and lime. Significant reductions in unit manpower requirements are achieved because of the increased efficiency of the entire operation. For example, manpower requirements to produce 10 tons of lime have been reduced to 1 man-hour when control is centered around the kiln—controlling raw material flows, sintering, fuel mixture, draft, temperature, and auxiliary equipment. Product quality and output capability are also improved substantially. In a ready-mixed concrete plant, switching from manual to centralized control of batching resulted in doubling its output with the same number of employees. Further extension of automatic control, by incorporating computers directly into the control system, is foreseen by some engineers. At present, a few computers are being used in the industry to furnish data necessary for accurate centralized control.

Plant and equipment outlays should continue to remain high. Expenditures for new plant and equipment were $224 million in 1964, the highest in the period 1958–64. Expenditures may continue at a high level during the next 5 years because of anticipated continued mechanization of operations throughout the industry and expansion in production facilities for prestressed concrete.

Manpower Trends and Adjustments

Employment is expected to continue to rise. Total employment increased from 140,100 to 172,100 between 1958 and 1964, rising at an average annual rate of 3.5 percent. Production worker employment increased at a slightly lower rate for the period, averaging 3.0 percent per year. Employment is expected to continue to increase as long as construction activity increases.

Changes in occupational structure will probably continue. The ratio of production workers to total employment has declined only slightly,

Average annual percent change	
All employees	
1958–64	3.5
Production workers	
1958–64	3.0
Output	
1947–57	8.2
1957–64	4.9

from 80 percent in 1958 to 78 percent in 1964. It is anticipated that this decline will continue but will not be accelerated to any great extent by increased mechanization.

Introduction of advanced machinery tends to change manual duties to machine-tending duties, to require new maintenance skills, and reduce manpower requirements in some occupations. Services of licensed boiler engineers and firemen, for example, are being eliminated by new systems of steam generation for autoclave curing. Manual laborers, called lime pickers, who are required to pick out unburned chunks of limestone from vertical kiln operations, are not needed on the increasingly popular rotary or circular-hearth kilns. With the introduction of a cubing machine, the jobs of laborers (cubers) who stack concrete blocks manually are eliminated and transferred to a machine operator. Functions of maintenance men are changing to include maintenance of instruments and electronic devices as well as mechanical equipment. In the concrete block industry, the offbearer man, a manual laborer who handles blocks in the curing process, is being replaced by a loading and unloading machine.

A key new job in the industry is the control-board operator. In the manual system of control, determining and maintaining the correct mix of raw materials, size of aggregate, and water content in the proportioning and mixing of concrete depend on judgment and experience of the batch man. In modernized plants, these variables are measured and automatically controlled. A control-board operator at a central console presets predetermined variables by turning set screws or entering punchcard information and monitors instruments on the console to verify the accuracy and consistency of the mix. Where corrections to preset specifications are indicated, he adjusts the proper dial, knob, or set screw. He must be able to make the necessary adjustments to produce custom mixes and odd size batches of concrete.

Prefabricated products are expected to continue to shift employment away from on-site construction. Increasing use of prefabricated concrete and gypsum products creates some new jobs in the concrete industry, while facilitating reductions of on-site manpower requirements in the construction industry. For example, in the production of concrete block panels for wall construction, an automatic block-laying machine manned by a crew of 3 (operator, wall finisher, and yardman) can lay 2,000 blocks a day—a work load that normally requires 10 masons and 5 tenders to perform.

On-the-job retraining plays an important part in adjustments to technological change. Although long-range planning for manpower adjustments is not typical, employees are usually transferred and retrained to handle new operations. However, one problem that has arisen with centralized instrument controls involves the training of skilled, manual operators who as console operators find difficulty in coping with complex panels displaying lights, dials, switches, and instruments.

Selected References

Technological Developments

Barton, William R. "Gypsum," *Mineral Facts and Problems, 1965 Edition,* Bureau of Mines, 1965.

Bell, Joseph N. "A Second Look at Expansive Cement," *Concrete Products,* June 1965, pp. 31–35.

Gertler, Sidney. "The Prestressed Concrete Products Industry," *Construction Review,* Business and Defense Services Administration, June 1961, pp. 5–12.

Gugliotta, Paul. "Modern Concrete Design," *International Science and Technology,* December 1963, pp. 54–61.

"Guide for Use of Epoxy Compounds With Concrete," *Journal of the American Concrete Institute,* September 1962, pp. 1121–1142.

Li, Shu-T'ien. "Expansive Cement Concretes—A Review," *Journal of the American Concrete Institute,* June 1965, pp. 689–706.

Lin, Tung Yen. "Revolution in Concrete," *Architectural Forum,* May 1961, pp. 121–127.

"New Markets for Lime," *Rock Products,* July 1964, pp. 93–95.

Pearson, A. S. and F. Asce. "Lightweight Aggregate From Fly Ash," *Civil Engineering,* September 1964, pp. 51–53.

Utley, Harry F. "Reno Operator Doubles Output With Remote, Automatic Setup," *Modern Concrete,* May 1965, pp. 64–65.

White, Roy C. and Edward J. Pokorney. "Automatic Technology in the Lime Industry," *Nonmetallic Minerals Processing,* November 1962, pp. 17–22.

"The Wonderful World of Epoxies," *Concrete Products,* November 1964, pp. 46–49 and 62.

Manpower Trends and Adjustments

"Block Laying Enters Machine Age," *Concrete Products,* January 1965, pp. 58–60 ff.

Miller, Harry J. "How a Florida Block Maker Cut His Curing Cost 46 Percent," *Modern Concrete,* April 1964, pp. 50–52 and 66.

"Technical Bulletin on Production Efficiency, 1962," Concrete Masonry Association, Arlington, Va., 1963, 9 pp. (mimeographed).

"Trends in the Use of Prestressed Concrete," *Construction Review,* Business and Defense Services Administration, January 1965, p. 11.

The Iron and Steel Industry (SIC 331)

Summary of Outlook Through 1970

Technological changes affecting a wide range of iron and steelmaking processes are being adopted. Major improvements in blast furnace operations include use of more highly beneficiated materials and supplementary fuel injection. Significant advances in steel production methods are basic oxygen steelmaking, vacuum refining, continuous casting, automatic controls, and general expediting of finishing operations. Increases in output per man-hour over the next 5 years are expected to exceed somewhat the 1957–64 average rate as continued high levels of capital spending result in the spread of recent technological advances.

Output is expected to increase at a slow rate. Employment may be lower, especially for production workers. Job opportunities will favor professional, technical, and skilled workers increasingly. Measures designed to alleviate the impact of technological change include extensive seniority provisions, extended vacations, early retirement, retraining programs, separation and layoff benefit plans, restrictions on subcontracting, and the Kaiser and the Alan Wood Plans of job security and sharing in benefits of technological change.

Outlook for Technology and Markets

Steel production is expected to increase at a slow rate. Steel ingot output increased from 84.9 million net tons in 1947 to 112.7 million net tons in 1957. In 1964, 126.9 million ingot tons of steel were produced, the highest on record. Output is expected to increase to about 135 million tons by 1970, according to some industry sources. Dollar sales may increase at a faster rate than tonnage because of the growing volume of "higher value" products.

Steel production is growing in Midwest area. Additional steel production facilities are being established in the Detroit–Chicago region to service the automobile, appliance, railroad, farm equipment, construction, and other markets. The Midwest steel demand is expected to grow relatively faster than total domestic demand over the next decade.

Steel imports are increasing. Imports of steel mill products amounted to only 1.2 percent of the total tonnage marketed in the United States in 1955, but by 1964 increased to 6.44 million tons, or 7.3 percent. Imports in 1965 will be about 10 percent of the market.

Higher performance, greater reliability, and closer tolerances are being obtained in steel products. Competition from such materials as aluminum, plastics, cement, and glass; and interest in meeting the requirements of the space, oceanography, defense and atomic energy programs are strong incentives to product innovation. Super-clean steels are being made by vacuum processes in order to develop improved physical and mechanical properties. Other new products are lightweight structurals, high strength maraging steels, plastic-coated steels to resist corrosion, thinner and stronger pipe, tin-free steel plate for container use, tin-coated steel foil 0.002 inches thick (thinner foil with gages of 0.0004 inches is experimental), and aluminum (or other metal) vapor coated steel, expected to be in production in 1966. One effect of these developments is to reduce overall steel user requirements in terms of weight. This tends to depress the rate of increase in ingot tonnage marketed.

Blast furnace productivity continues to increase. In 1950, the average output of pig iron per blast furnace day in the U.S. was 848 net tons compared to 1,182 net tons in 1960 and 1,444 net tons in 1964. Some new modern furnaces produce at a rate of more than 3,000 tons a day (the best furnaces were producing at about 2,000 tons a day 5 years ago), and one 4,000-ton-per-day furnace is now in operation abroad. The number of high-output blast furnaces, with probable lower labor requirements per ton of hot metal, is expected to increase.

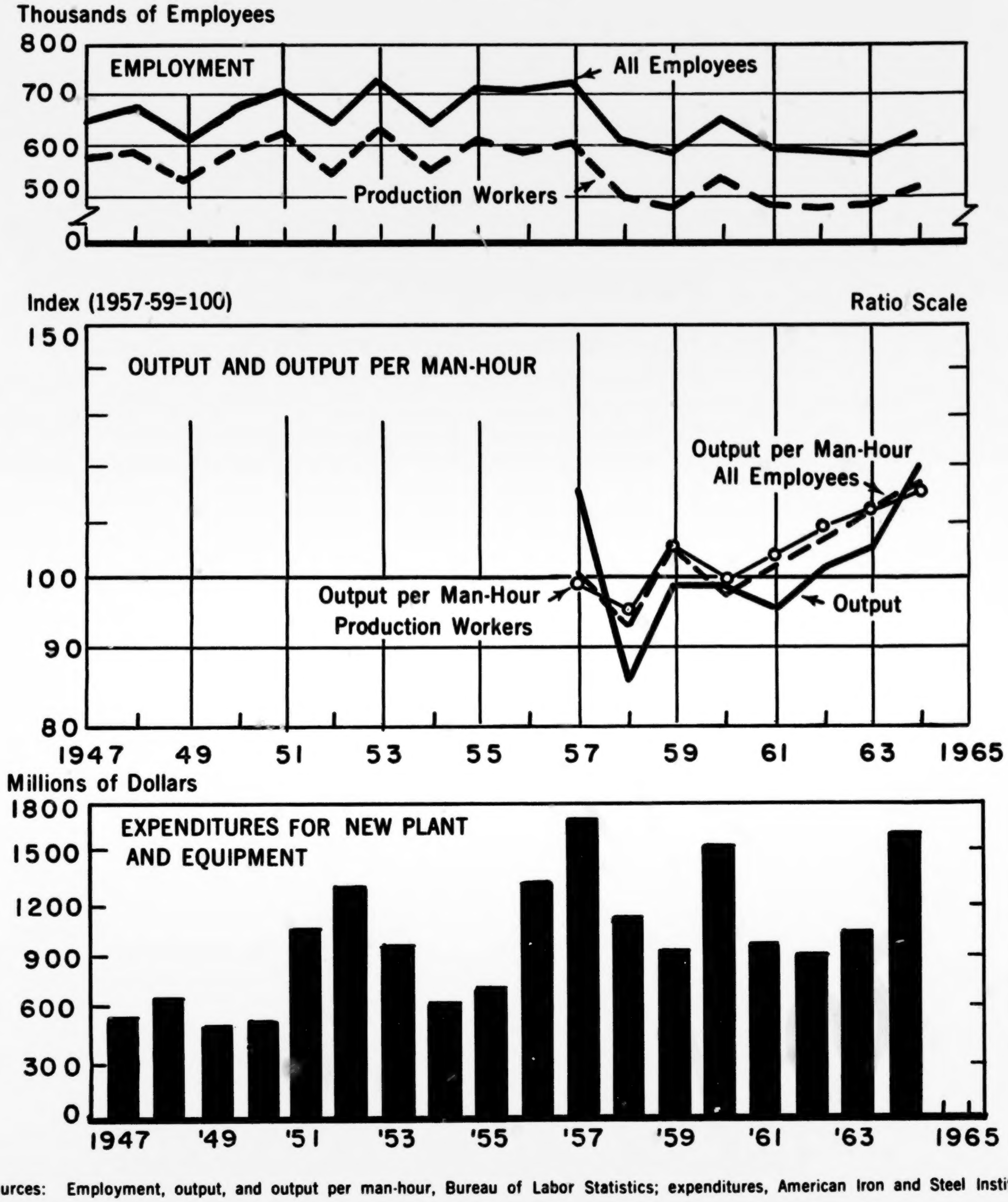
Beneficiated ores, especially pellets and sinter, are an important factor in increasing efficiency of blast furnace operations and improving metal composition. Total iron ore agglomerates (pellets, sinter, nodules, briquettes) constitute an increasing proportion of iron ore materials used in blast furnaces, rising from 28 percent in 1957 to 63 percent in 1964. Prepared feeds in 1964 included 54 million net tons of sinter and 29 million net tons of pellets, pellet production growing 421 percent between 1957–64 compared with 75 percent for sinter. Pellet production is expected to increase by 52 percent to about 44 million net tons by 1970. Self-fluxing iron ore agglomerates, simplifying blast furnace functions, also increase furnace efficiency. Successful automation of blast furnace operations may require preparation of all materials in the blast furnace charge, including more precise size, shape, and composition of coke, flux, and other charge materials. Economies in iron production are offset somewhat by the additional facilities and labor required in beneficiation and preparation of furnace burden materials. Some increase in employment may take place in the iron ore mining industry (SIC 101) as a result of the new beneficiation techniques making economically feasible the recovery, concentration, and agglomeration of low-grade iron ore (taconite) into pellets.

Injection of hydrocarbons (natural gas, oil, and coal), together with oxygen enrichment of the furnace blast, increases output and tends to lower furnace costs by partially replacing coke, a more expensive input. Since 1959, about 40 percent of U.S. blast furnaces have adopted some form of hydrocarbon injection, predominantly in the form of natural gas. An industry source states (January 1965) that 16 operating furnaces in the U.S. are equipped for fuel oil injection. Initial trials with coal injection indicate that coal could replace coke as a furnace fuel with an upper limit of about 20 percent replacement of coke or 30 percent when combined with higher blast temperatures and oxygen enrichment. Direct savings vary from plant to plant but could be significant because the cost of coal is roughly one-half that of coke. Difficulty persists, however, in the handling of the various supplementary fuels, especially coal.

The trend to higher output furnaces is aided also by the development of thinner but stronger refractories, extending the working volume.

Tons of white-hot pig iron are poured into the mouth of a 300-ton basic oxygen steelmaking furnace.

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN THE IRON AND STEEL INDUSTRY



Sources: Employment, output, and output per man-hour, Bureau of Labor Statistics; expenditures, American Iron and Steel Institute.

Capacity of blast furnaces is further expanded by the adoption of higher furnace top pressures, since gaseous reduction is increased, thus raising (shaft) efficiency.

By 1970, it is expected that the basic oxygen process could account for about 35 to 45 percent of the steel produced in the U.S., surpassing the output of open hearths. In 1964, basic oxygen production was 15.4 million tons, or 12.1 percent of the total, rising from 0.3 percent in 1955. In October 1965, there were at least 39 basic oxygen converters (37 basic oxygen furnaces, and 2 Kaldo or rotating furnaces) in the U.S., with at least 20 more being built or planned.

The basic oxygen process is being adopted because of lower production and capital costs, a faster production rate, and high product quality. Because of rapid changes in size and operating techniques, comparative costs of production vary over a wide range. Some estimates indicate average conversion costs (i.e., operating costs excluding metallics) for the basic oxygen furnace (BOF) of approximately $12 to $14 an ingot ton compared with $15 to $17 for most open-hearth shops. Initial capital investment is approximately $10 to $26 per ton annual capacity compared with $19 to $50 for open hearths and about $11 to $28 for electric furnaces. Oxygen costs are claimed to be generally lower than fuel charges for the open hearth or power for electric furnaces. Savings also accrue from the small physical size and simplicity of the BOF. Refractory consumption is less than 20 pounds per ton of steel compared with about 75 for the open hearth.

BOF cost savings are being extended by efforts to increase the economically feasible proportion of scrap used in this process (likely to remain a less expensive input than hot metal). Premelting of scrap may make possible a higher scrap charge than the standard 30 percent. Stainless and other highly alloyed steel can now be refined in basic oxygen furnaces.

The BOF has a high rate of output, turning out a "heat" of steel in less than 1 hour in contrast to 4 to 8 hours for the open hearth with oxygen practice, and 10 to 12 hours for the conventional open hearth. The average heat size is expected to increase from about 140 tons in mid-1965 to about 160 tons by 1967. (BOF's outside the U.S. averaged about 90 tons per heat in 1964.) Larger capacity basic oxygen furnaces with capacities from 250 to 300 tons are now in operation.

Industry replacement of open hearths by BOF's is on the order of one BOF for several open hearths. At one plant, two 250-ton BOF's with a combined annual capacity of 2.2 million tons are replacing 14 open hearths with a capacity of 1.9 million tons. Most of the new furnaces are replacing older units mainly to reduce costs and, to some extent, to expand capacity.

Replacement of open hearths by BOF's may be slowed by improved open hearth practices. Introduction of oxygen, faster charging, high firing rates, and the use of supplementary fuel (gas, oil) with oxygen (surface blown into the melt by means of oxy-fuel lances) are increasing output rates at low additional costs in open hearth furnaces. At least one-third of all open hearths use oxygen lances and make at least 60 percent of open hearth steel.

Continuous casting of steel is gaining acceptance. As of mid-1965, 9 continuous casting installations were in operation in the United States (2 on an experimental basis) and another 12 were under construction. Considerably less than 1 percent of all steel produced in the United States in 1965 was continuously cast, but there are industry estimates that by 1970, this ratio may reach 5 percent.

In continuous casting, molten steel is poured into the top of an oscillating mold, cooled with water spray, and an uninterrupted length of steel is withdrawn from the bottom in the form of semifinished products such as billets and blooms. Steps involved in pouring steel into ingot molds, stripping, reheating, and rough-rolling ingots into semifinished products are eliminated, resulting in a possible 30- to 50-percent capital investment savings over conventional ingot casting for certain grades of steel. Savings in operating cost are estimated at about 10 percent since yield of usable semifinished product per ton of molten metal is increased from 80–86 percent to 94–98 percent, labor requirements are considerably reduced, and utility requirements (oil, gas, power) are lower. Precise cost estimates in terms of both capital investment and operating costs are uncertain because of insufficient experience and rapid changes in technique associated with continuous casting.

Various economic and technical factors may impede adoption of continuous casting. Heavy investment in conventional equipment, lack of consistent quality in certain grades of steel, fear of premature obsolescence by reason of the fast-moving technology itself, and inability to handle large tonnage heats may deter rapid acceptance. Some plants will want to retain the flexibility of blooming and slabbing mills to facilitate serving a large variety of small orders.

In another form of direct casting—pressure casting—molten metal is forced through a refractory tube into a graphite mold. First introduced in 1963, pressure casting has almost as high a yield ratio as continuous casting and is said to be more flexible in the range of grades, sizes and shapes that it can produce although its laborsavings may be less. At least two plants now commercially produce pressure cast steel and four more units are being built.

Vacuum refining will be a growing practice. To improve product quality, steel is being refined by degassing or melting in vacuum chambers to remove trapped hydrogen, oxygen, and nitrogen. Improved fabricating characteristics plus mechanical and metallurgical properties are gained which broaden use of steel and extend the life of steel products. Bearings, gears, aircraft, and missiles which must have superior mechanical and physical properties are major applications. Also, surface quality improvements and an increase in the ability of the steelmaking plant to produce steels of unusual compositions may well extend the use of vacuum treatment for large tonnage items, such as carbon sheet steels.

At least 40 degassing units are in operation, most of them installed within the past 4 to 5 years. The two vacuum melting processes most in use are induction and arc (consumable electrode) melting. Between 1962 and 1964, combined vacuum induction and melting capacity rose to 600 million pounds from 500 million pounds.

Vacuum refining may be combined with the fast basic oxygen process and with continuous casting to facilitate the flow of clean steel through the continuous casting machine. Vacuum refining steel reduces hydrogen content to a very low level, permitting elimination of long, slow cooling cycles for some higher strength steels. Reduction (i.e., removal) of oxide inclusions improves rolling yields (possibly by 3 percent), metal workability, and surface finishes. Vacuum processes increase manpower requirements and add to refining costs, but these may be offset by the savings in the finishing department.

Computer usage has been rising rapidly. Some process computers are being used to collect and refine data for off-line analysis, some are used as laboratory research calculators, and others are used on-line, directly connected to the process through sensing or other signal devices that can prepare and display instructions to human operators. A trade journal article indicated at least 40 on-line process control computers as of 1963 in the steel industry—the first having been installed in 1959.

At least three blast furnaces have digital programing to initiate, monitor, and record the charging of raw materials into the blast furnace according to a predetermined ratio and at a certain rate. Much improvement has been made in probes and sensing devices for gaging stock level, temperature, and chemical composition, but continuous measurement of internal conditions within the furnace (as well as knowledge of smelting variables) is still insufficient for establishment of a workable closed-loop system.

In the basic oxygen process, control computers are used principally for calculating the proper charge of materials and for data collection. In some operations, computers control weighing and feeding of charge materials, lance position, oxygen flow rate, and blowing time. Possibility of complete closed-loop control for basic oxygen steelmaking is being advanced by improved instruments for continuous determination of batch temperature and carbon content.

A process control system has been applied with apparent success to an electric arc furnace to issue guide instructions for the operator to follow during the steelmaking process. The computer calculates charging practice, schedules and times furnace operations, and monitors and controls electrical load distribution for multiple furnaces.

Rolling and finishing operations are faster, more continuous, and increasingly automated. Of the 40 process computers listed by the 1963 survey, at least 21 of these control rolling and finishing operations (at least 8 in reversing mills, 7 in strip mills, and 6 in galvanizing, tin, and annealing lines). Results claimed are more consistent steel quality, reduction of scrap, faster changes in machine setup, faster processing, and lower costs. In advanced hot-strip mill systems, the computer automatically keeps track of slabs, sets the mill pace, determines mill settings, controls temperatures, and logs production data. About 12 more computers for hot-strip mills are being installed or manufactured.

Closed-loop controls, requiring only start-up by the operator, were successfully started on at least one annealing line in 1963. The computer directly controls furnace temperature and line speeds through feedback signals from a continuous hardness gage. According to one estimate, annual savings of $3 million to $5 million are possible from computer operation of a sheet mill of 1 million ton capacity. Considerable advances in inspection, testing, and quality control (electro-magnetic, X-ray, pneumatic, ultrasonic, and other automated or highly mechanized systems), and especially in in-process automatic inspection, have facilitated computerized operations.

Other developments speeding up production in rolling and finishing operations include a combination slab-plate mill that can be changed from slab to plate production in an hour, ultrasonic cleaning, and hydrochloric acid pickling. Improved products have resulted from such new finishing processes as vapor deposition of metals upon steel, annealing in special atmospheres, and processes to impart different surface textures and patterns to steel.

Expenditures for new plant and equipment are expected to reach record levels. Estimated 1964 expenditures of $1.59 billion are second only to the record of $1.72 billion for 1957 and compare with an annual average of $0.89 billion between 1947 and 1957, and $1.23 billion from 1957 to 1964. Capital expenditures are expected to be $1.7 billion in 1965, and to exceed $2 billion in 1966. A McGraw-Hill survey indicated that capital expenditures in the steel industry may average almost $2 billion annually over the next 10 years. At least two-thirds of the planned capital spending will be going toward replacement and modernization, compared with less than 55 percent for all manufacturing.

Research and development expenditures have risen considerably in the last few years. According to the National Science Foundation, funds for R&D in primary ferrous products reached $109 million in 1963, an increase from $64 million in 1957. The size of research staffs has tripled over the past 12 years. An estimated 6,000 scientists, engineers and supporting research personnel were employed by steel firms in 1964. Many steel companies have established laboratories for research and for development of new products and improvement of processes. Twenty-two steel companies are currently participating with the U.S. Bureau of Mines in metallurgical studies and in the operation of a small experimental blast furnace at Bruceton, Pa.

Manpower Trends and Outlook

Output per man-hour may increase at faster rates over the 1964–70 period than in 1957–64. Output per all-employee man-hour increased at an average annual rate of 2.4 percent (least squares computation) during 1957–64. The annual rate of increase for output per production worker man-hour was 2.3 percent. (These rates reflect the influence of changes in operating rate as well as in technology.) Between 1957 and 1964, output (as measured by the BLS composite index) increased at a rate of 1.7 percent a year (least squares computation).

Diffusion of technological advances and rising production probably will result in an average rate of increase in output per man-hour between 1964 and 1970 that exceeds the 1957–64 average. Output is expected to grow at a faster rate also. According to a McGraw-Hill study (in April 1965), various major producers (assuming an economy growth of 3.5 percent) expect an average gain of 2.5 percent a year in output (as indicated by steel shipments) between 1963 and 1975; if the economy grows at a 4-percent rate, the rate would be 3 percent a year.

The level of employment, particularly for production workers, may be lower in 1970 than in 1964. Employment in 1964 was 629,400, the highest since 1957 (except for the post-strike year 1960). The 1964 level, however, was 90,500 (or 12.6 percent) below the 1957 level.

Production worker employment declined relatively more than total employment so that the ratio of production workers to all employees declined from 83.4 percent in 1957 to 82.0 percent in 1964. Between 1947 and 1957, while total employment increased by 64,100, the ratio of production workers to all employees declined from 87.7 percent to 83.4 percent.

Average annual percent change *	
All employees	
1947–57	0.9
1957–64	–1.9
Production workers	
1947–57	.5
1957–64	–2.2
Output	
1957–64	1.7
Output per all-employee man-hour	
1957–64	2.4
Output per production worker man-hour	
1957–64	2.3

* Based on the least squares trend of the logarithms of the index numbers.

Occupational distribution is undergoing a change in favor of professional, technical, and skilled workers. Between 1950 and 1960, according to Census data, cutbacks in laborers, service workers and operatives occurred; the number of professional and technical workers increased substantially and skilled craftsmen and foremen remained about the same.

The number of unskilled and semiskilled workers, about 70 percent of all employees, is expected to decrease over the next 5 to 10 years at a faster rate than overall employment. Opportunities for skilled plant personnel will probably rise, especially for maintenance workers, as machinery and instruments become increasingly complex. However, as a result of new methods and pushbutton operations, some jobs requiring a high degree of skill (e.g., the "first helper" in steelmaking furnaces) have been replaced by jobs having lower skill requirements. Expanding R&D programs provide prospects for engineers, scientists, laboratory aides, and other technical personnel. Electronic computer programers and personnel trained in data processing for computer-controlled machines will be in demand.

Some Issues and Examples of Adjustment

Collective bargaining agreements are providing greater job and income security. Extensive seniority provisions include early retirement: a worker who is 55 or more years old and whose combined age and length of service equal 75, or any employee who has at least 15 years of continuous service and whose combined age and years of service equal 80, may retire on immediate pension; any employee who is 40 or more years of age and who has 15 or more years of service who is affected by shutdown is eligible for a deferred vested pension at age 65; according to the 1965 agreement, effective August 1, 1966, employees with 30 years' service can retire on full pension regardless of age.

An extended vacation plan became effective in 1964 to provide 13-week vacations every 5 years for the senior half of the workers in each contracting company. This plan has been modified by the 1965 collective bargaining agreements to enable employees to take pay instead of time off for a portion of the 13 weeks.

Agreement provisions aimed at job security include restrictions on subcontracting, and discussion of limitations on overtime work while employees are on layoff.

The Kaiser Steel (1963) and Alan Wood (1965) Plans are designed specifically to provide protection in event of layoffs and income loss as a result of technological change. Employees also are given a share in cost savings from production efficiencies.

A number of protective arrangements exist to help the worker facing layoff or termination. Over 50 percent of the major collective bargaining agreements in the steel industry in 1962, covering 83 percent of all workers, contained severance pay or layoff benefit plans. Supplementary unemployment benefits (SUB) are provided in all major bargaining agreements. SUB plans now provide compensation for a short workweek.

Job transfer can now occur without loss of seniority rights, although transfer may involve movement to an unskilled status. Interregional job transfers under the 1965 agreement were extended to include employees with 5 years of service or more. Moving allowances were increased substantially for those who relocate to a plant at least 50 miles from the former job.

Training and retraining programs are being provided for jobs made more complicated by modern technology. At one company, for example, a program has been in effect since 1962 to retrain electrical personnel for efficient maintenance of modern electrical equipment and controls. These updating and upgrading programs consist of classroom and laboratory training of up to 5 years. Most companies conduct some form of apprenticeship program to meet their maintenance requirements. There are such programs for about 20 different crafts in the steel industry, usually of 3 to 4 years' duration, consisting mainly of shop training and classes. Under the 1965 bargaining agreement, joint industry-union committees will be set up to study apprenticeship programs, retraining, and testing of personnel.

Selected References

Crabtree, S. A. "Steel Finishing," *Iron and Steel Engineer,* November 1963, pp. 84–87.

Current Wage Developments, No. 213, BLS, Sept. 1, 1965, pp. 1–2.

Forrest, A. G. "Nondestructive Testing: A Progress Report," *Blast Furnace and Steel Plant,* January 1965, pp. 37–43.

Gallagher, L. V. and Old, B. S. "The Continuous Casting of Steel," *Scientific American,* December 1963, pp. 2–16.

Impact of Steelmaking Trends on Suppliers, Battelle Memorial Institute, Columbus, Ohio, Oct. 30, 1964.

Indexes of Output Per Man-Hour, Steel Industry, 1957–63, Bureau of Labor Statistics, November 1964. 17 pp.

Kirkland, R. W. "Process Computers—Their Place in the Steel Industry," *Iron and Steel Engineer,* February 1965, pp. 115–124.

Kobrin, C. L. "Blast Furnaces Charge Back," *The Iron Age,* June 17, 1965, pp. 59–63.

Madsen, I. E. "Developments in the Iron and Steel Industry During 1964," *Iron and Steel Engineer,* January 1965, pp. D–1 through D–78.

McGannon, Harold E., editor. *The Making, Shaping and Treating of Steel,* 8th edition, 1964, United States Steel Corp., Pittsburgh, Pa.

McManus, G. L. "The Direct Casting Controversy," *The Iron Age,* August 5, 1965, pp. 53–57.

Miller, W. E. "Application of Automation and Automatic Techniques to Metal Rolling and Processing," *Blast Furnace and Steel Plant,* August 1964, pp. 692–699 and 705.

Oram, J. E. "Summary of Recent Automation Developments in the Iron and Steelmaking Process," *Iron and Steel Engineer,* April 1965, pp. 139–144.

Selected References—Continued

Price, F. C. "The New Technology of Iron and Steel," *Chemical Engineering*, Sept. 14, 1964, pp. 179–194.

Stone, J. K. "LD Basic Oxygen Steelmaking—Its Growth and Development," *Journal of Metals*, August 1963, pp. 20–23.

"Vacuum Degassing: Key to Better Steels," *Metal Progress*, September 1964, pp. 74–80.

Wage Chronology: U.S. Steel Corporation 1937–64 (BLS Report 186, Revised 1965). 42 pp.

The Foundry Industry (SIC 332, 336)

Summary of Outlook Through 1970

Foundry expenditures for new plant and equipment are increasing as the outlook for sales of castings to automotive and other metalworking industries improves. Continuing improvements in the various steps of existing foundry technology are expected to lead to substantial increases in efficiency. Major changes underway include further diffusion of improved equipment and processes, greater mechanization of materials handling, and a continuing trend toward greater concentration of production in larger, more efficient foundries. Increases in employment may continue; however, such a trend depends on the rate of growth of the metalworking industries. Unskilled occupations will likely be reduced while technological changes may be expected to generate additional employment in technical and maintenance work.

Outlook for Technology and Markets

Production of castings is expected to continue the rise which began in 1962. This upward trend in growth is due to the anticipated expansion of production in the motor vehicles and parts, machine tool, industrial machinery, and other industries within the metalworking sector—which, combined, consume approximately two-thirds of all castings produced. Output of iron and steel (ferrous) castings (Federal Reserve Board index) increased at an average annual rate of 1.6 percent between 1957 and 1964, exceeding the rate of 0.3 percent for the 1947–57 period. The growth rate for nonferrous castings was 1 percent between 1957 and 1964, but between 1961 and 1964, was 7.6 percent. During the 1947–57 period, nonferrous castings output increased at the rate of 2.4 percent a year.

Changing technologies in other industries may reduce the market for some castings. For example, the growing use of continuous casting in steel production, which eliminates ingot molds, will affect adversely the market for this gray iron foundry product. Steel industry experts speculate that by 1970 about 5 percent of steel output may be continuously cast, compared with considerably less than 1 percent in 1965. In addition, growing acceptance of competitive materials such as plastics and nylon may, in certain uses, such as automobile instrument panels, result in their substitution for nonferrous castings, particularly diecastings.

Advances in foundry metallurgy are strengthening the position of founding as a metal-forming process. Many metal parts, formerly produced by competitive processes such as forging, welding, and stamping are being redesigned as castings. For example, automobile crankshafts and connecting rods, long produced only as steel forgings, are being cast successfully in the improved casting materials, pearlitic malleable and nodular (ductile) iron. Shipments of nodular iron, which is also being used increasingly for cast iron water and gas mains, increased over 200 percent between 1958 and 1964. These shipments accounted for 3.4 percent of total gray iron shipments in the latter year while those of pearlitic malleable iron in the same period increased from 18 to 26 percent of all malleable iron shipments.

The casting process is being relied on increasingly in the manufacture of small, intricate parts and in the shaping of hard-to-machine alloys used in aerospace applications. The hardness of the alloys used in jet engine blades, for example, precludes, economically and often technically, any other method of fabrication.

The trend is toward fewer but more mechanized foundries. Historically, a large number of highly competitive, small firms with little capital have produced a wide range of different shapes and sizes of castings in small lots. Over 50 percent of all foundries in 1962 had fewer than 20 employees, and over 70 percent, fewer than 50. The total number of foundries rose from 5,452 in 1946 to a postwar high of 5,758 in 1956, then decreased at a fairly steady rate to 5,029 in 1964.

This decline in the number of foundries between 1956 and 1964 has been due, in large measure, to the closing of smaller foundries. Foundries with fewer than 20 employees accounted for over 60 percent of this decline. Some further displacement of small, inefficient foundries may be expected as the trend toward fewer but more mechanized producers continues.

Continued mechanization of materials handling is expected to be one of the major factors in reducing man-hour requirements. The continuing introduction of materials-handling equipment, such as conveyors and trucks, may be expected to reduce foundry unit labor requirements substantially, and to mitigate the impact of the expected increase in output on employment. Various types of conveyor installations, for example, are reported to reduce man-hour requirements by at least 50 percent in metal pouring, to as much as 90 percent in the handling of sand and dry bond materials.

In molding and coremaking, the growing use of pneumatic and other types of conveyors, sand feeders, and mold and flask-handling equipment may also reduce labor requirements per unit of output. According to a recent industry survey, within 2 years the number of foundries with mechanized sand-handling systems will increase from 32 to about 45 percent, while those with mechanized mold-handling facilities will increase from 15 to approximately 25 percent.

Improvements in speed, capacity, and automaticity of molding machines continue to increase significantly the efficiency of conventional sand molding. Advances include faster mold cycles, increased numbers of machine-controlled functions, larger flasks that can accommodate an increased number of different patterns simultaneously, and adaptability to automated mold handling. From 20 to 25 percent of all foundries, annually for the past several years, according to industry surveys, have indicated plans to purchase molding machines, a higher percentage than for any other type of foundry equipment.

One new machine, suitable for jobbing foundries, for example, increases the number of patterns accommodated per flask from two to four, and is capable of doubling output per man-hour. The greatly increased productivity of the newer molding machines is reflected in the decline of about 20 percent in the number of sand-molding machines between 1959 and 1963, despite the continuing predominance of casting by the sand-molding method.

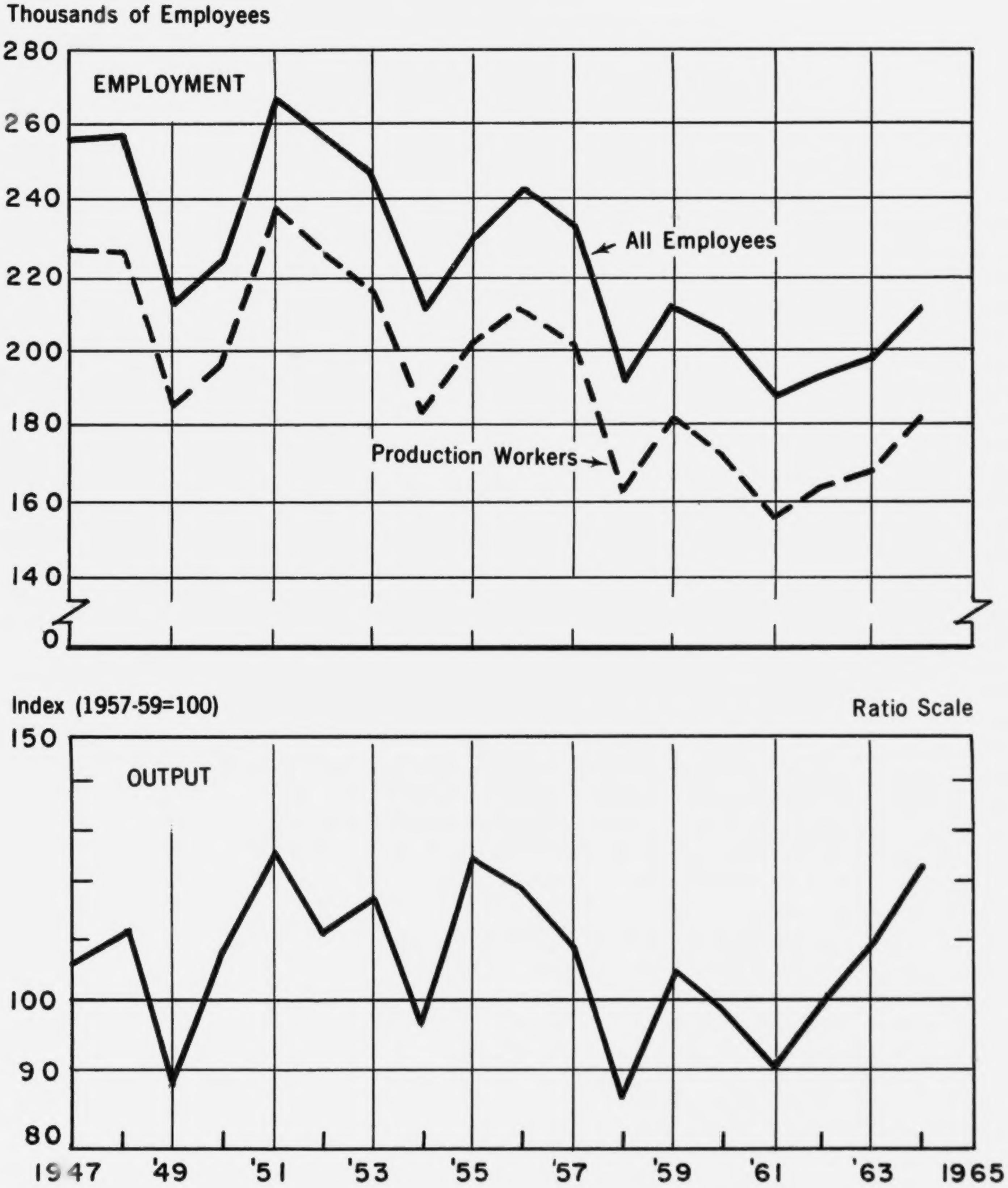
Some experts see an eventual trend toward flaskless molding for small castings in production foundries because of its potential substantial savings from the elimination of handling and storage of flasks. Recently, several of these machines have been installed, largely on an experimental basis.

Specialized methods of molding are expected to increase, but only gradually. Industry experts estimate that specialized methods, which include the shell, CO_2, and investment and other ceramic processes, are used for only 5 to 10 percent of all castings produced. The greater costs of these specialized processes, due to more expensive binders and patterns and/or the additional investment necessary for special equipment, are expected to continue to restrict their use. Applications are likely to remain limited to instances where economies may be obtained in subsequent machining, where extremely close dimensional tolerances are a primary consideration, or, as in the case of the investment casting of extremely hard alloys, where no other method of fabrication is practicable or even possible.

Although the shell process also offers the advantages of reducing significantly the amount of sand and handling required in conventional molding and adaptability to a higher degree of mechanization, its economic application is generally limited to mass production foundries. Of the 5,029 foundries in the U.S. in 1964, only 578 were using the shell process in molding—a 15-percent increase over 1958.

Growth of the CO_2 process—essentially a replacement of conventional (oil) binders with sodium silicate which is cured by penetrating the mold with carbon dioxide gas—may be adversely affected by the recent introduction of air-setting and self-curing resin binders which are being used increasingly for molds of all sizes. A total of 757 foundries—7 percent more than in 1958—were using this process in 1964.

EMPLOYMENT AND OUTPUT IN IRON AND STEEL FOUNDRIES



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board

The relatively substantial recent increase—42 percent since 1958—in the number of foundries using the investment (lost wax) process, the most precise but least mechanized of all casting methods, reflects a growing reliance on it for the fabrication of intricately designed small parts and hard-to-machine alloys. Only 265 foundries in 1964, however, were involved.

Specialized processes and improved sand binders are likely to reduce man-hour requirements in coremaking. Use of the shell and CO_2 processes is expected to remain greater in coremaking than in molding because, in addition to providing improved surfaces and dimensional accuracy, they eliminate the baking operation—a time and labor consuming step in conventional coremaking. In 1964, 1,208 foundries used the shell process and 1,451 the CO_2 process for coremaking—increases of 113 and 25 percent, respectively, since 1958.

The use of air-setting and self-curing resin binders in coremaking is expected to expand. The main application of these new bonding materials probably will be the replacing of oil binders in conventional coremaking for larger castings and small quantity production. The use of resin binders results in increased core quality in many applications and significant reductions in curing time. The "hot box" process, another relatively new coremaking method, is growing in use in high production foundries. This process substitutes thermosetting resin binders for conventional binders.

Coremaking is becoming increasingly mechanized. Improved core blowers, shooters, and shell core machines are being introduced more extensively to replace manual coremaking and older equipment. Features such as faster operating cycles, simultaneous production of several cores, and adaptability to improved coremaking materials make possible substantial reductions in man-hour requirements. The introduction of a double cavity core blower—adapted to produce "hot box" cores—can more than double the core output. The greater productivity of new machines is reflected in the decline of about 10 percent in the number of coremaking machines in use between 1959 and 1963, without a reduction in coremaking capacity. This trend will probably continue.

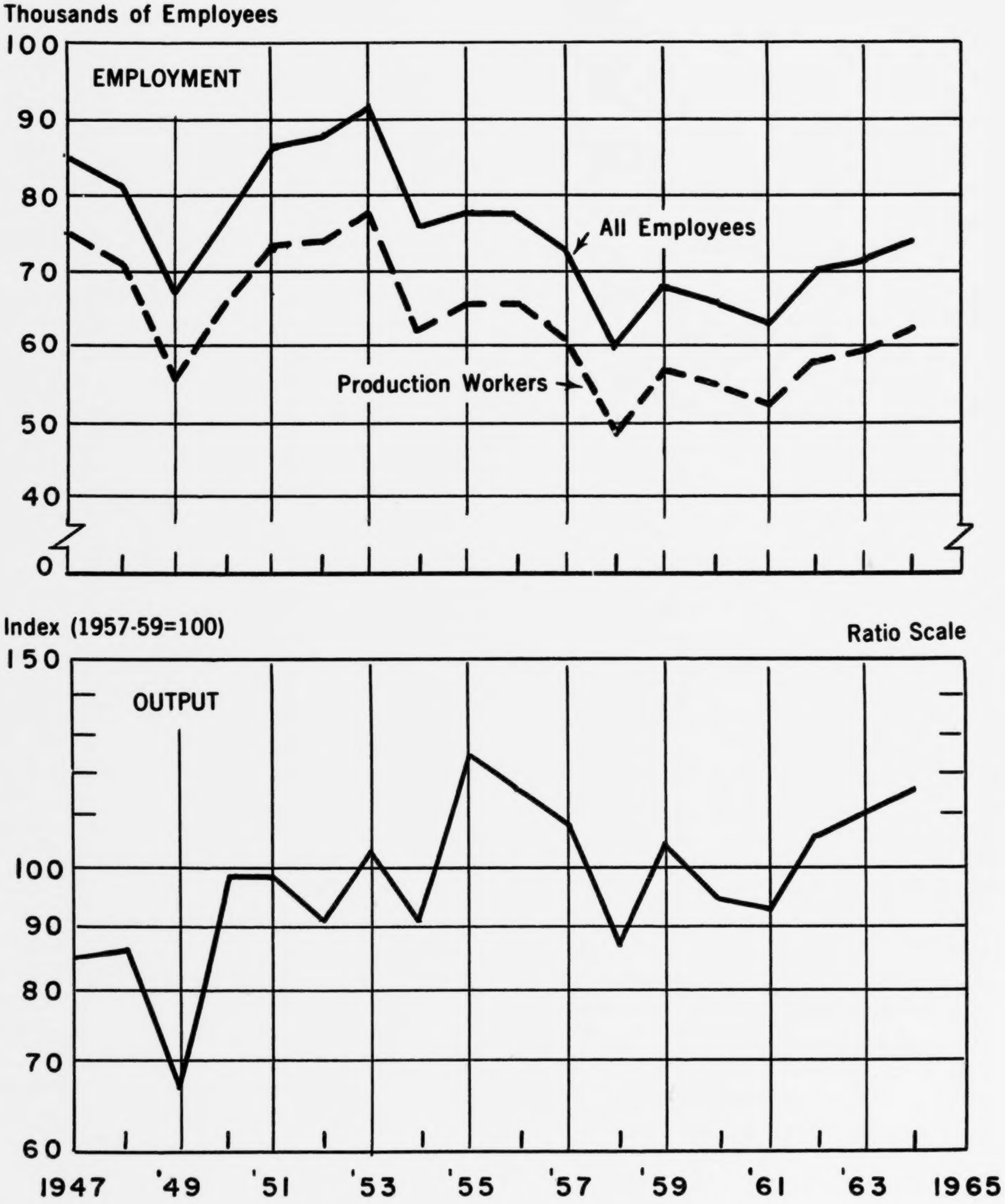
Larger machines and more automatic control are foreseen in diecasting. Machines of greater size are expected to permit an increase in the number of cavities per die and in the size of the cast part. Steps in the process such as metal feeding, casting removal, and die lubrication will probably be controlled automatically in an increasing number of foundries, improving casting quality and leading to further increases in output per man-hour. The greater efficiency resulting from continued adoption of such advances is reflected partially in the increase of 21 percent in output of diecastings between 1959 and 1963 while the number of diecasting machines remained virtually constant.

Limited to the casting of nonferrous metals, diecasting accounted for 53 percent of the total output of nonferrous castings in 1964, compared with 46 percent in 1957 and 29 percent in 1947. Because of the growing ability of the process to produce larger size castings, its share of total nonferrous output is expected to continue to increase. Since diecasting is generally more highly mechanized than the methods it replaces, further reduction in man-hour requirements in nonferrous casting can be expected.

The use of electric melting furnaces is increasing. The close control of melt temperature, increased use of scrap metal, and flexibility of batch type melting, afforded by electric melting, is leading to greater use of electric furnaces both as primary melters and refining units. The number of electric furnaces in use more than doubled between 1947 and 1963; they account for more than one-half of total steel castings production and a significantly smaller but growing proportion of iron castings output. Cupolas, which are also being improved, will probably remain the principal units for melting iron in large quantities and are expected to be used increasingly in combination with electric holding furnaces.

Instrumentation is being improved and expanded. Increasing emphasis on improved product quality and efficiency of operation is ex-

EMPLOYMENT AND OUTPUT IN NONFERROUS FOUNDRIES



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board.

pected to result in continued growth in the use of precision instruments, including radiographic (X-ray), supersonic, pyrometer, and radioisotope units in such operations as melting, sand preparation, and inspection. Between 1953 and 1963, for example, the number of radiographic units in use more than doubled.

The use of computers for accounting and production functions is expected to increase, although at present only a few of the large foundries have these facilities. In addition to data processing for determining sand mixes, furnace charges, and melting cycles, some experts foresee computers applied in preparing data for tape control systems used in connection with molding and coremaking operations.

Investment in plant and equipment is increasing. Expenditures for new plant and equipment have followed an irregular course since 1947, but generally have risen in years when output has increased. Continuing growth in expenditures over the next few years, while depending greatly on future expectations, may accompany the anticipated increasing output of the industry. The index of new equipment orders, prepared by the Foundry Equipment Manufacturers Association, showed that expenditures in 1964 were more than twice their 1957–59 level. Eighty-three percent of the respondents in a recent survey of gray iron foundries indicated plans to make a major or substantial capital investment in 1965; in 1960, only 40 percent indicated similar plans.

More attention is being directed to research and development (R&D). Expenditures for R&D by the foundry industry, although relatively small, are increasing. Extensive studies are being carried on in automotive technical centers in such areas as basic metallurgy, molding materials and methods, process control, and production equipment. Expanded research programs are also being conducted by the Steel Founders' Society of America, the Malleable Founders Society, the Gray and Ductile Iron Founders' Society, Inc., and other associations, for their respective segments of the industry, and by the American Foundrymen's Society for the total industry. For example, the American Foundrymen's Society recently increased its budget for research and reorganized its research council to promote more effective industrywide research, establish closer liaison with Government research in metallurgy, and coordinate its research activities with nonfoundry technical societies in areas of common interest.

Manpower Trends and Adjustments

Employment is expected to rise above present levels if recent growth rates of castings output continue. Iron and steel foundry employment (excluding foundries operating as a part of another establishment) decreased from 233,500 in 1957 to 212,000 in 1964, or at an average annual rate of 1.4 percent compared with a rate of decline of 1 percent between 1947 and 1957. Nonferrous foundry employment (excluding foundries operating as a part of another establishment) rose slightly from 73,000 in 1957 to 74,300 in 1964, or at an average rate of 0.3 percent a year following a decreasing rate of 1.6 percent between 1947 and 1957. In both the ferrous and nonferrous sectors, employment increased significantly between 1961 and 1964 at average annual rates, respectively, of 4.3 and 5.3 percent.

The proportion of production workers to total employment is relatively high in foundries, comprising 86 percent in 1964 in the iron and steel foundries and 83 percent in the nonferrous foundries. The proportions are only slightly lower than in 1947.

Upgrading of occupational structure is expected to continue. Engineers, metallurgists, and technicians are increasing in number as a result of the growing emphasis on improved mechanization, technology, and quality control. Employment in these occupations more than doubled between 1958 and 1963, and represented nearly 4 percent of foundry employment in 1963.

Increased mechanization may be expected to continue to alter occupational skills as well as reduce man-hour requirements of molders and coremakers. These occupations, which include the highly skilled hand molders and coremakers,

Nonferrous foundries

	Average annual percent change
All employees	
1947–57	−1.6
1957–64	.2
Production workers	
1947–57	−2.2
1957–64	.3
Output	
1947–57	2.4
1957–64	1.0

Iron and steel foundries

	Average annual percent change
All employees	
1947–57	−1.0
1957–64	−1.4
Production workers	
1947–57	−1.3
1957–64	−1.5
Output	
1947–57	.3
1957–64	1.6

accounted for about 13 and 6 percent of total foundry employment, respectively, in 1963.

The continuing mechanization of materials handling will probably increase the number of equipment operators and maintenance men while reducing the number of unskilled laborers. Materials-handling workers constitute the largest foundry occupational group, accounting for about 20 percent of total foundry employment in 1963.

Training of employees is receiving increased attention. In-plant training, particularly on-the-job instruction, is expected to remain as the chief means of updating skills of present employees and of filling new positions created by technological advances. In addition, expanded formal training programs, such as those sponsored by the Training and Research Institute of the American Foundrymen's Society, provide technicians and key production personnel with courses to keep abreast of changing technologies such as hydraulic and electronic controls. In an effort to attract technical personnel to foundry work, the scholarship program of the Foundry Educational Foundation is being broadened to include scholarship grants for technical school training as well as engineering grants for university study.

Some key collective bargaining agreements provide income maintenance for displaced workers. Supplemental unemployment benefit plans were contained in 10 of 19 agreements in force in 1963, each covering 1,000 or more foundry workers; provisions for severance pay were included in 6. Such payments have proven helpful to workers displaced in the closing of obsolete plants.

Selected References

Technological Developments

"Looking Forward to 1975," *Foundry,* May 1965, pp. 104–125.

"New Dimensions in Metalcasting," *Modern Castings,* April 1964, pp. 83–100.

"New Glow in the Foundry," *Dun's Review and Modern Industry,* August 1962, pp. 30–32 ff.

"Census of Casting Plants," *Foundry,* April 1965, pp. 56–59.

"Inventory of Foundry Equipment," *Foundry,* April 1964, pp. 116–125.

Begeman, Myron L. and B. H. Amstead. *Manufacturing Processes.* New York, John Wiley and Sons, Inc., 1963. pp. 43–140.

Cook, Glenn J. *Engineered Castings.* New York, The McGraw-Hill Book Company, Inc., 1961. 257 pp.

Selective References—Continued

Manpower Trends and Adjustments

Case Studies of Displaced Workers (BLS Bulletin 1408, 1964), pp. 79–88.

"People in Foundries—1975," *Foundry*, May 1965, pp. 118–121.

U.S. Department of Labor, Bureau of Apprenticeship and Training. *Foundry Training Needs* and *Foundry Training Needs, Job Foundries,* 1956 and 1957. Also summarized by John S. McCauley in *Monthly Labor Review,* October 1957, pp. 1224–1228.

Ammer, Dean S. *Mechanization and Manpower in Gray-Iron Foundries* (prepared for the Office of Manpower, Automation and Training, U.S. Department of Labor). Bureau of Business and Economic Research, Northeastern University, 1965. 234 pp.

The Aluminum Industry (SIC 3334, 3352)

Summary of Outlook Through 1970

Improvements in the conventional electrolytic-reduction method, such as increases in the size of cells and anodes and greater use of additives, are expected to continue. Progress is expected in the development of processes for direct reduction of bauxite to aluminum. Continuous casting, production of sheet from pellets, nondestructive testing and semicontinuous annealing are important advances in rolling, drawing, and extruding. Transportation of molten metal to large users may increase.

Rapid expansion in output is expected to continue for the next several years. Output per man-hour (data available only for primary production, SIC 3334) is expected to continue increasing at a high rate, reflecting a rising level of capital expenditures for additional capacity and modernization. Employment will probably stabilize at mid-1965 levels as reduction in unit man-hour requirements is offset by growth in output.

Outlook for Markets and Technology

Recent trends suggest rapid growth in output will continue. The Bureau of Labor Statistics index for primary aluminum output increased at an average annual rate of 11.4 percent over 1947–57 period. Between 1957 and 1963, the average annual growth was 5.7 percent, primary production reaching 2.55 million tons in 1964.

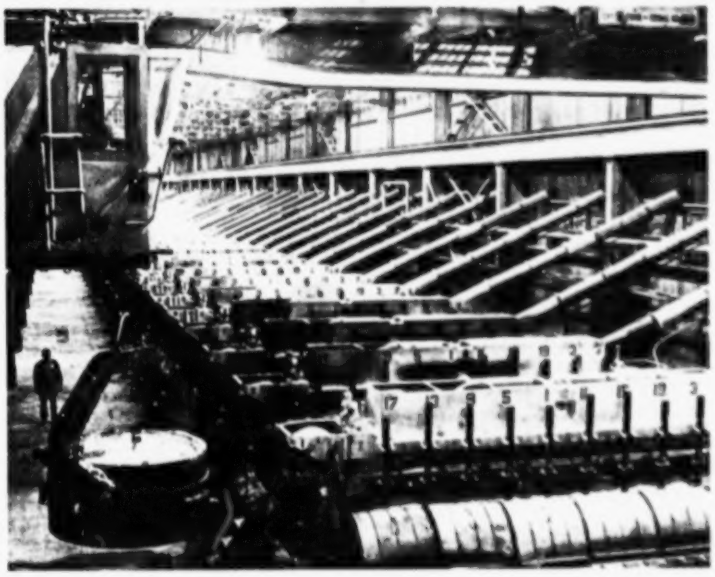
In the fabrication sector (rolling, drawing, and extruding, SIC 3352), the Federal Reserve Board index showed growth in production of semifabricated aluminum products (sheet, plate, rod, bar and wire) at an average annual rate of 7.2 percent for 1947 through 1957, and 8.5 percent per year, 1957 through 1964.

Resources for the Future, Inc., on the basis of data terminating in 1960, projections anticipate growth in the industry at annual average rates of from 3.5 to 7.8 percent for 1960–70. Production data for more recent years indicate the higher rate to be the more likely.

Demand for aluminum in many markets is rising, in competition with steel, plastics, wood, glass, and copper. In construction, aluminum is increasingly used for nonstructural building facing, siding, window frames, and roofing, in place of steel, wood, and concrete. Demand for aluminum in pipe is increasing as indicated by such varied orders as those for culvert and irrigation pipe and the 2-mile adjustable horizontal support pipe for the copper accelerator tube in the Stanford Linear Accelerator.

The high strength-to-weight ratio of aluminum contributes to its growing importance in transportation equipment. Aluminum used in the average passenger automobile in model year 1964 was estimated at 72.4 pounds, a 2.4-pound gain over 1963, and estimates are that the use in the 1965 model year will average 74 pounds. Slightly more than one-half of truck bodies are now being made of aluminum. Use in truck trailers, mobile homes, railroad containers, and freight cars, new rapid transit trains, superstructures for passenger and freight marine vessels, structures for small pleasure boats and for aircraft, underscore the increasing importance of aluminum in transportation.

The use of aluminum in electric power transmission lines, and for some consumer durables such as air-conditioners is expanding. Citrus juices are marketed extensively in aluminum



Overhead crane moves a crucible of molten aluminum which has just been removed from electrolytic reduction cells.

cans; tops for beer cans are now being made of aluminum, although the containers are still mostly tin-plated steel. Thin aluminum sheets are used in a sea water desalinization process. The metal has also a wide variety of uses in the space program. In the highly competitive area of containers and packaging, use in 1964 was 16.7 percent above the 1963 level and 48 percent above 1962.

According to the Aluminum Association, the 1964 distribution of shipments was as follows with respect to end purpose: building products —23.5 percent of total shipments; transportation equipment—22.3 percent; electric equipment—11.7 percent; consumer durables—10.7 percent; containers and packaging—8 percent; machinery and equipment—7 percent; export—8.1 percent; and other consumers—8.7 percent.

New processes for primary production are being perfected. Several new processes are being explored in an effort to achieve one or more of three objectives: to bypass the high capital costs entailed in electrolytic-reduction, to produce aluminum economically from a lower grade of bauxite, or to use the clays abundant in the earth's crust as a source of aluminum. Two promising methods, the subchloride and the fused alumina processes, bypass the electrolytic-reduction phase, reducing bauxite directly to aluminum.

The subchloride and fused alumina processes now in pilot plant operation could be placed in commercial operation by 1970. Capital costs of these and other new processes may be one-half to two-thirds those of the conventional electrolytic-reduction process, although the cost of electricity may be about the same as for the electrolytic process. Labor requirements are not clearly indicated, but operating labor could be reduced per unit of output by the use of larger individual process units, while at the same time maintenance labor requirements might be somewhat higher.

An abundance of high grade bauxite, and the large capital expenditures for those new processes retaining electrolytic-reduction, are deterrents to their intensive development. The conventional Bayer-Hall process is expected to continue as the principal bauxite reduction process.

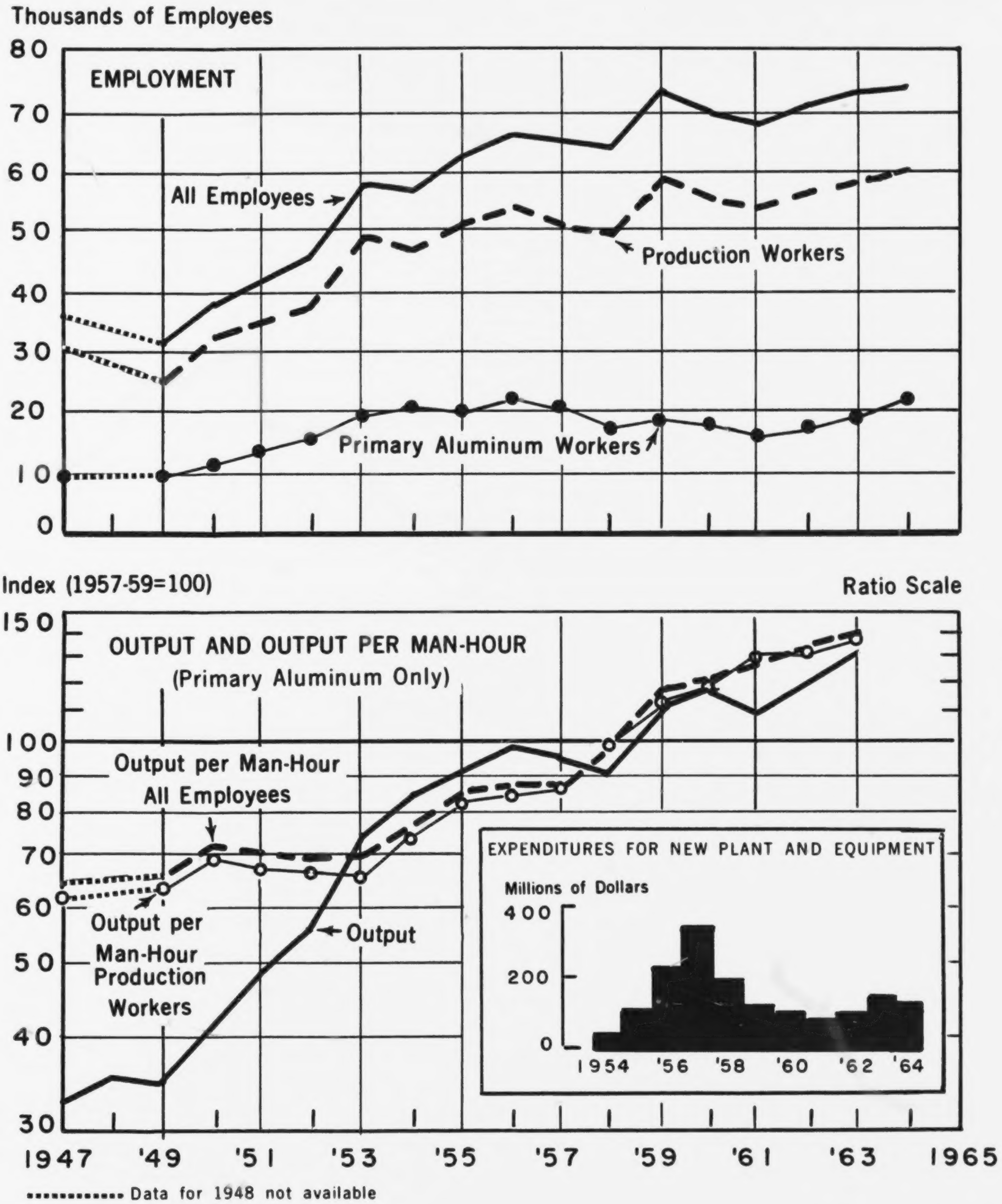
Improvements continue to be made in the 75-year-old Bayer-Hall electrolytic-reduction process. The conventional method of producing aluminum is a two-step operation in which bauxite is processed mechanically and chemically to obtain alumina, which is then electrolytically reduced to the metal, aluminum. New plants and older plants undergoing expansion are incorporating cells (in reduction phase) that are larger and have improved design. The increase in size of cells and anodes, plus development of new materials for refractory linings, are expected to extend the interval between cell rebuilding and the changing of anodes, thus saving labor. Alloying is being done in reduction cells (60 percent of the 1964 primary output), eliminating the need for separate furnaces for this purpose. One company reports that use of additives such as lithium fluoride increases the efficiency of cells up to 15 percent by shortening reduction time and decreases unit labor costs. More wide spread use of additives depends largely on lower prices.

Continuous casting, fusing of pellets, and blow-molding are expected to affect both semifabricating and end product fabricating. Continuous casting, first developed in nonferrous operations in the 1930's, has only recently been used in aluminum fabrication to produce substantial quantities of rod, bar, strip and plate. It is estimated that 15 to 20 sheet, and 8 to 10 bar and rod machines are in operation; additional units are expected by 1970.

Continuous casting eliminates the need for ingot casting, storage, and soaking pits, the molten aluminum going directly from reduction cells or alloying furnaces to casting wheels or belts where it is cast and cooled before being run on rolling stands. The lower capital costs of continuous casting could induce some end product fabricators to integrate backward for the production of their own semifabricated stock. One end product fabricator claims large savings from backward integration.

However, because some alloys and products cannot be fabricated by continuous casting, this method is expected to remain supplementary to standard facilities. Conventional stands will continue to be used in the larger mills, those producing from 750,000 to 3 million pounds per

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN THE ALUMINUM INDUSTRY



Sources: Employment and expenditures, Bureau of the Census; output and output per man-hour, Bureau of Labor Statistics.

year, because they can be used to produce more varied products than can the continuous casting units. Some large companies are establishing single product line mills which may be expected to continue the increases in the efficiency of the industry.

Blowmolding is an experimental technique for shortcutting conventional canmaking processes. This technique would bypass the making of sheet, forming the can directly from molten metal. If successful, this method, which uses a machine costing around $100,000, could effect substantial manpower and capital savings.

A new technique developed in 1963 fuses aluminum pellets into sheets up to 36 inches wide. Like continuous casting, pellet fusing eliminates the need for heavy ingot casting, storage, and breakdown facilities. The lower capital costs entailed in this technique may result in backward integration of small and medium end product fabricators. Such fabricators would buy pellets from primary producers, and heat and compact them into sheets for their own use.

Nondestructive testing allows better production control. Radiographic testing, using magnetic lines of flux, and ultrasonic testing, which reveal interior irregularities of cast and rolled products, are being rapidly adopted. Such new methods make possible rapid correction in the production process to achieve a more consistent product. Economies are effected, according to reports, because closer control of production results in scrap saving and higher average grades of metal.

Annealing shifts toward continuous processing. In conventional batch handling methods, metal coils are annealed and cooled in the same furnace, the whole cycle requiring from 12 to 14 hours. Improvements in the batch method involve three chambered furnaces in which three coils of metal may be in different stages of the cycle. The three chambers contain a common inert atmosphere to prevent staining. The first chamber serves to pre-heat the metal before it enters the second, or annealing chamber; the third chamber is used to cool the annealed coils. This method cuts the time for the complete cycle by one-half. Only one installation is in use, but wider adoption is expected.

In another recently developed process, strip metal up to one-eighth inch in thickness floats on a directional air stream that suspends and heats the metal, cooling it as it moves down the line. The whole process can be completed in seconds. Although information on rate of flow is not available, the fact that only 2 men are needed to tend the strip line, whereas 10 men are needed for conventional batch handling, indicates significant labor saving. Two major installations are in use.

Transportation of molten metal cuts costs. Aluminum is now being sold and transported as molten metal, thus eliminating the costs of casting by primary producer and those of remelting by the purchaser. Molten metal use is feasible only for large users, since there is a critical scheduling problem. In 1964, one major producer of primary aluminum sold 13 percent of its production in the form of molten metal to automotive casting plants.

Computers aid in production and office work. At one plant, alloy metal proportions are determined by computer in order to produce metals with particular mechanical properties. Guesswork is eliminated and uniform quality is maintained from melt to melt. In another plant, application of computers to office work has, in addition to reducing the clerical force, resulted in more rapid preparation of control reports to management on inventory and sales; aided in production scheduling; and halved the time formerly required to close the books at the month's end.

Advances in the electric power industry allow aluminum producers to locate near markets. The production of aluminum consumes vast amounts of electric power; the cost of power, therefore, influences choice of plant location. Recent advances in the technology of steam generating power plants have made it possible to locate new plants in the Ohio River Valley, close to the major markets.

A significant increase in capacity is planned. Capital expenditures in the industry were $143.8 million in 1963 and $124 million in 1964. Substantially higher levels are expected in the next few years. The announced expansion in primary capacity in excess of 500,000 tons and the need for facilities to fabricate the additional metal are cited by some experts as indicating that capital expenditures will total about $1 billion between 1965 and 1970. The capacity of the primary aluminum industry in 1970 is expected to be about 3.8 million short tons—the amount required to sustain the 1957–64 growth trend in primary output with facilities operating at 95 percent of capacity. This would be an expansion of about 50 percent over 1963 capacity.

Research and development expenditures are expected to increase. Competition from other metals and from nonmetals is expected to stimulate research and development. Technical advances of foreign competitors may also spur R&D in an effort to avoid the necessity for licensing arrangements with foreign firms for newly developed processes. From an estimated $30 million in 1962, R&D expenditures are expected to increase to about $70 million annually by 1975.

Manpower Trends and Adjustments

Output per man-hour will continue to increase rapidly in primary production (SIC 3334). Output per all employee man-hour increased at the annual rate of 3.1 percent from 1947 through 1957, and 8 percent from 1957 through 1963. For production workers only, the rate was higher from 1947 through 1957—3.5 percent; it was 8 percent for 1957 through 1963. The sharply higher rate for both groups in the more recent period reflected the impact of new capacity built since 1954. Growth probably will continue at this high rate as new plants and methods are introduced.

Total employment is expected to remain fairly stable for primary production (SIC 3334) and rolling, drawing, and extrusion (SIC 3352). Total employment (Census data) in both sectors rose from 36,300 in 1947 to 76,400 in 1964. For 1947 through 1957, the average annual gain in employment was 6 percent for all employees and 5.4 percent for production workers. For the years 1957 through 1964, the average annual rate of gain slowed to 2.3 for all employees and 2.6 percent for production workers.

Employment in primary production reached its peak, 21,100, in 1956. Employment declined from 20,500 in 1957 to 18,133 in 1963, rising in 1964 to 20,295, still below the 1957 high. In rolling, drawing, and extruding, employment increased from 44,458 in 1957 to 56,063 in 1964, an average annual increase of 3.4 percent.

	Average annual percent change
All employees	
1947–57	6.0
1957–64	2.3
Production workers	
1947–57	5.4
1957–64	2.6
Output	
1947–57	11.4
1957–63	5.7
Output per all-employee man-hour	
1947–57	3.1
1957–63	8.0
Output per production worker man-hour	
1947–57	3.5
1957–63	8.0

New techniques may cause backward integration and shift some employment to other industries. Continuous casting and pellet fusing, by cutting capital requirements necessary to form molten metal into semifinished products, may induce end product fabricators to merge in order to gain economies inherent in these techniques that eliminate need for conventional heavy equipment. Molten metal transportation to casting plants owned by the automotive industries could shift some employment from aluminum to the automotive industry.

Early retirement is possible under the 1965 collective bargaining agreements. Retirement with full benefits is possible after 30 years of service. Workers may, after 2 years away from the job because of plant shutdown, extended layoff, or disability, elect to retire if their age and continuous service total 75 at age 55; or, if their age and continuous service total 80 or more, they may retire at any age. They will receive a $100 monthly supplemental pension in addition to the regular monthly pension to which they will be entitled. This supplemental benefit will be paid until the worker is entitled to receive full social security benefits.

Supplementary unemployment benefits (SUB) are available. When laid off, workers covered by the agreements receive SUB for a maximum of 1 year at a rate which will bring their total benefits (State and SUB) to 60 percent of their average weekly wages.

Extended vacations were started in 1964. Under collective bargaining agreements concluded in 1963, one-half of the employees in each department who were eligible on the basis of seniority, for regular vacations on December 31, 1963, were vested with an extended vacation of 10 (consecutive) weeks with 13 weeks pay, effective January 1, 1964. Coverage is to be extended annually so that those employees who become qualified for regular vacations in 1966, 1967, or 1968 also become qualified for extended vacations. The company, insofar as practicable, is to schedule employees for extended vacations in approximately equal numbers each year, such vacations to be granted once in each 5-year period. The provision for 10-week extended vacations, negotiated in 1963, has necessitated the training of men to replace those who are on extended vacation, according to officials of one plant.

Selected References

Addison, H. et al. "Explosive Welding of Aluminum Alloys," *Welding Journal,* August 1963, pp. 359–364.

Cleaver, J. M. "Productivity in an Expanding Industry," *Monthly Labor Review,* April 1965, pp. 373–377.

"Computer bares secrets of quality: Asarco's aluminum smelters," *Steel,* July 29, 1963, p. 90.

"Continuous casting line crops aluminum costs," *Steel,* November 26, 1962, pp. 84–85.

"Costs for building and operating aluminum producing plants," *Chemical Engineering,* September 2, 1963, pp. 120–121.

Klein, Frederick C. "Alcoa, Steel Union Sign Three Year Pact Averting Strike; Firm Raises Prices of Nearly All Fabricated Products," *Wall Street Journal,* June 1, 1965.

"Siphon transfers molten aluminum; system prevents oxidation during semicontinuous casting," *Iron Age,* March 5, 1964, pp. 68–69 .

Smith, J. M. "The Aluminum Engine . . Let's Take Another Look," *SAE Journal,* October 1964, pp. 90–95.

Stamper, J. W. "Aluminum 1963," *1963 Minerals Yearbook,* Bureau of Mines, U.S. Department of the Interior, 1964.

"The Aluminum Industry: Its Problems and Progress," *Economic Review,* Federal Reserve Bank of Cleveland, March 1964.

"Traveling Mold Casting Machine," *Light Metal Age,* April 1964, pp. 11, 22.

The Electrical Machinery, Equipment, and Supplies Industry (SIC 36)

Summary of Outlook Through 1970

Output will probably continue to increase at the rate of the past few years, but could rise faster if defense and space expenditures rise sharply. Major technological advances underway which are expected to reduce unit labor requirements in certain operations include miniaturization of electronic components and circuits, mechanization of assembly, and continued improvements in metalworking production and materials handling equipment. Product innovations for business communication, industrial automation, and consumer services are also likely to be frequent. Employment is expected to rise, with a substantial increase expected for scientists, engineers, and technicians. R&D outlays will continue to rank among the highest in industry.

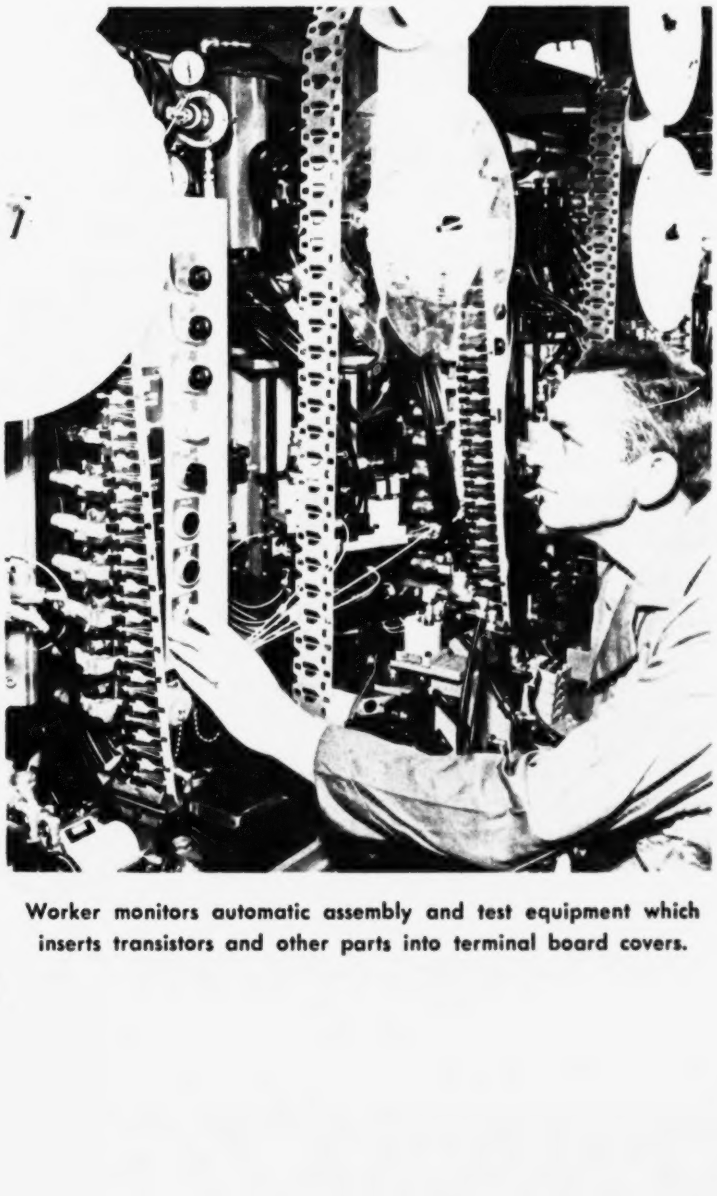
Outlook for Technology and Markets

Production of electrical machinery and equipment is expected to continue to increase at the present rate. Production (FRB data) increased at an average annual rate of 4.8 percent between 1957–64; this was below the average annual increase of 7.1 percent during the 1947–57 period. Output (in terms of total value of shipments) amounted to $31 billion in 1964, over 50 percent accounted for by 3 of the 8 SIC major subindustry groups—communication equipment, household appliances, and electronic components. Production will probably continue to increase near the 1957–64 rate over the next 5 years, rather than at the high rate of the first postwar decade. The rate of growth, however, may be raised by a higher level of defense and space expenditures and by continued growth in exports of electrical machinery and equipment.

Product improvements continue to provide new markets. The anticipated rapid growth in sales of color TV sets, for example, is attributed mainly to improved picture quality, lower retail prices for color sets, and an increase in number of color TV programs. In 1966, some industry sources forecast that sales of color TV sets may rise to over 5 million sets, compared with 1.4 million sets in 1964, and that by 1970, color sets may comprise about 50 percent of the total TV sets in use in American homes, compared with 10 percent in late 1965.

New growth markets for manufacturers of communication equipment are arising from the development of business communication devices such as data phones, facsimile transmission apparatus, telemetering equipment, and the substitution of electronic telephone switching for electromechanical systems. By the mid-1970's, a major manufacturer of communication equipment expects production of electronic switching systems to account for the bulk of its total production of these devices.

The development of solid state components, microcircuits, and other electronic devices is broadening applications of industrial process instruments and controls. These new electronic components which operate faster and are smaller, lighter, and more reliable than tubes



Worker monitors automatic assembly and test equipment which inserts transistors and other parts into terminal board covers.

and other conventional components, also are facilitating further quality improvements and market acceptability of computers, numerical control systems, and other products using electronic components.

Electronic components such as printed circuits, transistors, and microcircuits involve more widespread use of chemical and metallurgical processing that replace mechanical manufacturing and assembly. Although mechanical assembly is still needed, the production of printed circuit boards, for example, replaces a substantial amount of mechanical wiring necessary in conventional circuits by chemically etching circuits on the copper foil surface of boards of various laminates such as paper or plastics.

In contrast to the production of conventional tubes where assembly is a major task, the manufacture of transistors, their substitutes, involves principally the chemical-metallurgical process of "growing" silicon-germanium wafers and assembly is less important.

The present trend to more widespread use of microcircuits, involving even more extensive chemical-metallurgical processes, will substitute further these processes for mechanical manufacturing and assembly. Some experts foresee excess capacity in conventional machining and assembly facilities as chemical-metallurgical processes become more widespread.

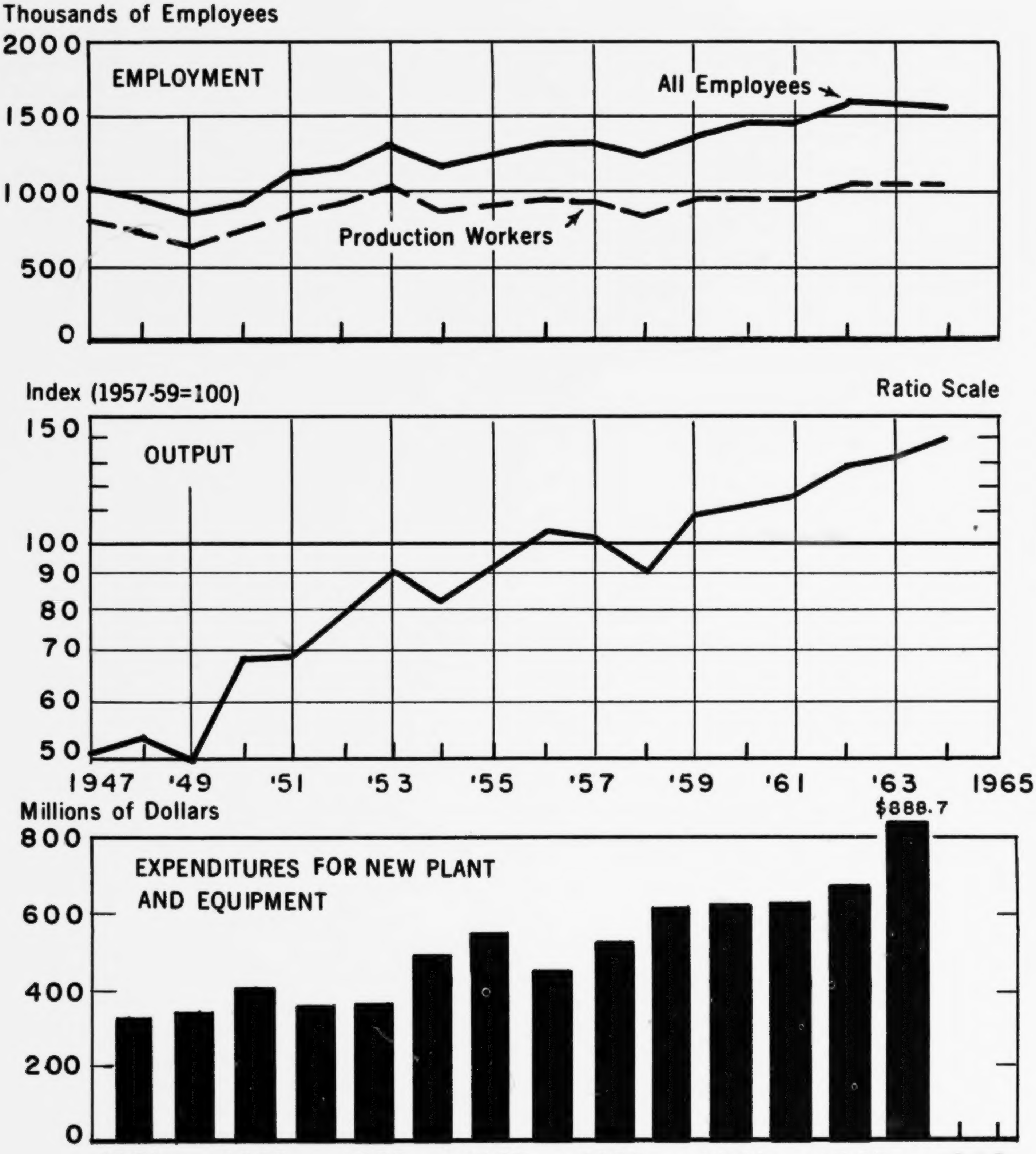
Use of microcircuits is expected to become widespread. Microcircuits change radically the conventional method of mass wiring and assembly of separate transistors, capacitors, resistors, and other components that form a complete circuit. Essentially, they are miniaturized electronic circuits consisting of a tiny latticework of thin metal conductors mounted on material such as glass or silicon. Microcircuits eliminate many individual components and many manual assembly operations, such as hand wiring, needed in making conventional circuits, and offer greater reliability, smaller size, less weight, and lower power consumption. Since they can be produced by even more automatic equipment and processes than conventional circuits, labor savings are anticipated.

First developed for missiles and satellites, commercial and industrial application of microcircuits is growing and in 1965 may equal or surpass military and space applications. Currently they are used principally in electronic computers, but their use is expected to expand to instruments, industrial controls, and mass-produced consumer products. According to one trade forecast, total sales of microcircuits may reach $210 million by 1968, more than four times 1964 sales. Further adoption of microcircuits may slow the growth rate of component production from nearly 10 percent a year during recent years, to about 4 percent a year during 1967–72. This decreasing demand for components may cause an increasing number of component-producing firms to move into microcircuit production.

Numerically controlled machine tools are likely to be used more widely. Between 1954 and 1963, 335 numerically controlled machine tools were shipped to the electrical machinery industry—a very small proportion of all machine tools in the industry; 49 percent were shipped after mid-1962. The largest number of numerically controlled tools have been installed in plants making communication equipment. Numerical control is a technique of automatically operating and controlling machine tools through a system of electronic devices and coded instructions on tape. This makes possible substantial reductions in unit labor requirements, tooling costs, lead time, and inventories relative to those required by conventional machine tools. Some examples disclose unit laborsavings of 25 to 80 percent, and savings in tooling costs of up to 85 percent. Numerical control, particularly suitable for the manufacture of different parts in small volume, also offers greater flexibility of production. The outlook for further adoption of numerically controlled machine tools in the electrical machinery industry is very favorable, with significant implications for the nearly 150,000 workers in machining occupations.

Mechanization of assembly may become a major factor in reducing man-hour requirements in mass-produced items. Since assemblers comprise the largest occupational group in the industry—about 18 percent of all production workers—continued emphasis on further mechanization of component assembly, some of

EMPLOYMENT, OUTPUT, AND CAPITAL EXPENDITURES IN ELECTRICAL MACHINERY, EQUIPMENT AND SUPPLIES



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board; expenditures, Bureau of Census.

which is already done by machine, is anticipated. A recently installed assembly line, for example, consists of conveyor-connected machines which automatically insert a component onto printed circuit boards, and automatic inspection machines. The result was a reduction in assemblers from 100 to 2, and an increase in production of more than 30 percent.

In the production of end products such as electronic instruments, TV sets, radios, and home appliances, where assembly is less mechanized than in component manufacture, significant laborsavings, and improved product quality are being achieved by the introduction of new soldering, welding, fastening, indexing, and component feeding equipment.

Improved metalworking production equipment and continuous flow lines are being more widely adopted. Advances include increased speed, an increased number of machine-controlled functions, adaptability to mechanization of materials handling, and the combining of separate operations in all types of production equipment. One new combined drilling and tapping machine, for example, reduced eight separate operations for making fractional horsepower motors to two, with expected labor cost savings of as much as 60 percent. In the production of household electric lamps, a new automatic unit operated by 2 workers—1 feeding and 1 inspecting—replaced machinery requiring 30 workers for the same rate of output.

Laborsavings are also being achieved by more widespread adoption of continuous flow lines, consisting of separate units of automatically controlled production equipment (such as welding, bending, forming, punching, and metalcutting machines) connected by the mechanized transfer of parts. For example, a large firm recently increased productivity and capacity substantially by introducing an electronically controlled production line—containing nine different production operations—for the fabrication of refrigerator and freezer doors.

Computers are being used widely for data processing and to a limited extent for production control. According to a 1965 McGraw-Hill survey of large companies, 93 percent of the electrical machinery companies who supplied data reported at least one computer installation—amounting, in all, to 422 computers, or 13 percent of the total number of computers reported for all manufacturing. Major applications include accounting, inventory control, and production planning. Computers are also being used in connection with control of production processes, such as assembly of circuits and production of resistors. Twenty-seven percent of the responding companies reported computers applied for this use.

Expenditures for research and development will continue to increase. R&D expenditures in the electrical equipment industry (SIC 36) and its chief industrial customer—communication (SIC 48)—reached $2.5 billion in 1963, an increase of 64 percent over 1956 outlays (National Science Foundation data). In 1963, they accounted for 20 percent of the total R&D funds for industry, second only to such outlays in the aerospace industry. About 63 percent of this research was financed by the Federal Government. R&D expenditures will likely continue to rise to higher levels in future years, one estimate projecting a level of $6.4 billion by 1974. Among the areas of research are space technology, nuclear propulsion, laser technology, process control systems, and new products for home and industry such as microwave cooking equipment, wall TV sets, ultrasonic dishwashers, video tape recorders, and medical electronic instruments.

Capital spending may continue to rise. Capital expenditures for new plant and equipment reached $889 million in 1964, rising steadily each year from a level of $450 million in 1958. Investment in the electronic components and communication equipment segments accounted for 51 percent of the industry's total expenditure in 1963. A McGraw-Hill survey of future plans projects an industry total of $3.3 billion from 1965 through 1968, or an average of over $800 million annually. Investment for modernization and replacement is estimated to become even more important, rising from two-thirds to nearly three-fourths of planned total spending. However, programs for expansion of capacity remain significant. For example, one large firm plans to spend $50 million to double color TV tube and receiver output over the next 3 years by adding new production facilities and creating 2,000 new jobs.

Manpower Trends and Adjustments

Employment is expected to increase. Total employment increased at an average annual rate of 2.6 percent between 1947 and 1957, and increased at the slightly slower rate of 2.0 percent from 1957 to 1964. Total employment in 1964—1,548,400—however, was slightly lower than the number employed in 1962, primarily reflecting the sharp employment decline in the communication equipment sector (employing about one-fourth of total industry employment), largely the result of cutbacks in government defense purchases. Total and subindustry employment in 1965 indicated a reversal of this downward trend. Production worker employment followed the same general pattern during these periods, increasing at an average annual rate of 1.1 percent from 1957 to 1964. Relatively high rates of growth in output, particularly in electronic products, will probably lead to higher levels of employment.

Occupations requiring special training will continue to increase. Production worker jobs have been increasing more slowly than administrative, sales, technical, professional, and clerical jobs. Production workers as a percent of total employment declined from 78 percent in 1947 to 67 percent in 1964. This ratio probably will continue to decrease, but at a slower rate.

Employment of scientists, engineers, and technicians is increasing as research and development programs are enlarged, and manufacturing techniques and products become more complex. Employment of R&D scientists and engineers in the electrical equipment and communication industries (SIC 36 and 48) increased by more than 75 percent between 1957–64, and is expected to increase by another 16 percent by 1968 to about 88,000. The number of machinery repairmen, numerical control and computer programers, and tool and die workers—jobs requiring special training—will also continue to increase.

The rate of growth of employment opportunities for assemblers and machine operators may be slowed. The proportion of women assemblers, comprising about two-thirds of the total, however, probably will increase because of their aptitude for miniaturized assembly and microscopic "white room" work. Laborers, such as materials handlers, are likely to decrease because of further mechanization of materials handling.

Average annual percent change	
All employees	
1947–57	2.6
1957–64	2.0
Production workers	
1947–57	1.7
1957–64	1.1
Output	
1947–57	7.1
1957–64	4.8

Production workers are a significantly smaller proportion of total employment in plants producing military-space electronic products. A BLS survey made in 1965 found that production workers comprised 32 percent of the total work force in establishments making military-space electronic products, compared with 61 percent in electronic firms making components, 60 percent in consumer products, and 57 percent in firms making industrial-commercial products. Substantially smaller proportions of semiskilled assemblers, inspectors, and testers are found in the production of military and space items, and a significantly larger proportion of engineers and technicians.

Job security and facilitating adjustment to new technology are receiving increased emphasis in labor-management negotiations. Of 98 major agreements studied in the electrical machinery industry, 37 in 1963, covering 223,000 employees, had provisions for severance pay and layoff benefit plans. Under requirements of a typical plan included in this study, employees must have completed at least 1 year of company service to be eligible for graduated benefits which vary with length of service.

Joint union-management "Automation Committees" have been established under a few agreements and some objectives are: To assess the manpower impacts and requirements of new technology; to study the adequacy of the job evaluation system for new technologies; to explore and recommend methods to minimize displacement; and to make recommendations for sharing the benefits of technological change.

Training is becoming increasingly important. Changing products, equipment, and processes require training for a wide range of occupations and skills, including production and maintenance personnel, supervisors, technical salesmen, technicians, engineers, and scientists. Training programs are also an important means for providing new skills to workers displaced by new technology. In addition to traditional on-the-job training, some large companies emphasize formal classroom training on company premises, specially developed correspondence courses, and evening vocational and college courses.

Selected References

Technological Developments

Dulberger, Leon H. and Joel A. Strasser. "Electronics Markets—1965," *Electronics,* Jan. 11, 1965, pp. 87–110; see also pp. 123–125.

Electronic Industries Association, *Electronic Industries Yearbook, 1964,* (Washington, D.C., 1964), 73 pp.

"Fabricating Sheet Metal Cylinders in Motor Frame Production," *Automation,* January 1963, pp. 58–60.

Hittinger, William C. and Morgan Sparks. "Microelectronics," *Scientific American,* November 1965, pp. 57–70.

LaFond, Charles D., Michael Getler, and Rex Pay. "Special Report on Microelectronics," *Missiles and Rockets,* Feb. 3, 1964, pp. 23–63.

"One Plant Does the Work of Three," *Factory,* September 1964, pp. 106–108.

"Tomorrow's Plant Now," *Business Week,* Aug. 1, 1964, pp. 52–53, 56.

"Two Operations Replace Eight—Dual-Unit Machine Cuts Drilling and Tapping Costs," *Machinery,* February 1965, pp. 113–114.

Manpower Trends and Adjustments

Automation in General Electric—The Human Side of the Story. General Electric Company (New York, N.Y.), 30 pp.

Docken, F. L. "Make Change a Part of Training," *The Iron Age,* Feb. 18, 1965, pp. 87–89.

Employment Outlook and Changing Occupational Structure in Electronics Manufacturing (BLS Bulletin 1363, 1963), 61 pp.

"Is Incentive Pay Headed for the Shelf?" *Business Week,* June 27, 1964, pp. 51–52.

International Union of Electrical, Radio and Machine Workers, AFL–CIO. *President's Report to the Eleventh Constitutional Convention.* (Washington, Sept. 21–25, 1964), 285 pp.

The Motor Vehicles and Equipment Industry (SIC 371)

Summary of Outlook Through 1970

Technological advances are continuing in practically all phases of motor vehicle production. Important changes include numerical control and electronic machining, and mechanical part assembly. Expanding research and development programs are emphasizing advanced types of engines and computerized systems for design and engineering.

A major capital investment program to expand plant capacity is underway. Technological changes are expected to continue to reduce unit labor requirements, but future employment levels will also depend on the volume of motor vehicles output. Output is expected to be higher in 1970 than in 1964. However, output projections vary; as a consequence, estimates of the level of employment in 1970 are uncertain. Employment has risen since 1961, reversing a downward trend that began in 1953.

Outlook for Technology and Markets

Output of motor vehicles is expected to reach higher levels. Unit factory sales of domestically produced passenger cars, trucks, and buses (Automobile Manufacturers Association data) increased at an annual average rate of 4.2 percent from 1947 to 1957 and continued to increase at the slightly lower rate of 3.7 percent a year from 1957 to 1964. During the more recent period, 1961–64, a period of sustained growth, unit sales grew 11.6 percent annually. Sales during the first half of 1965 indicate another peak production year. Rising disposable income, the growing number of multicar families, an increasing number of eligible drivers, increasing use of trucks for short and long hauls, and a high automobile scrappage rate (5.8 million automobiles in 1964), will probably continue to increase demand for motor vehicles. Industry and other private forecasts of automobile sales by 1970, for example, range from 9 to 12.5 million units, 16 to 61 percent above 1964.

Mass production transfer machines are being made increasingly flexible. New transfer lines permit greater product flexibility than older equipment by incorporating multipurpose machines which, with a minimum of adjustment, can produce a number of variations of a given part. For example, two or three different engine blocks can now be machined on the same production line.

Flexibility is being achieved also by designing storage areas for parts in process. This permits shutdown and maintenance of individual working stations without stopping the entire transfer line. Flexibility and significant savings in retooling costs are also being achieved by introducing "building-block" transfer lines, constructed from machinery and equipment consisting of interchangeable standardized modular units. These lines can be modified to accommodate changes in parts design or retooling for car model changes, with a minimum of delay. In addition, the number of automatic operations performed on lines is increasing, including the time-consuming functions of gaging and inspection.

Numerically controlled machine tools are being introduced. Numerical control—a technique of

Engineer uses electric pencil to modify automobile design in experimental computer design system.

automatic operation and control of machine tools by electronic devices and coded tape instructions—particularly suitable for manufacture of parts in small volume, has not found widespread application in this mass production industry. Between 1954 and 1963, 194 numerically controlled machine tools were shipped to the motor vehicles and equipment industry, a very small fraction of the about 76,000 machine tools installed in the industry. Numerical control is expected to be used increasingly for the vital function of fabrication of the tools and dies needed in operating the industry's many high-volume parts producing machines, since faster and more economical retooling processes and a greater degree of flexibility in design change are made possible.

Electrical discharge and electrochemical machining are likely to be used more widely. In contrast to the conventional machining techniques, applying mechanical force and cutting tools, these new electronic metal removal processes utilize electrical energy to shape metal parts. In 1963, a total of about 100 electrical discharge and electrochemical machine tools were being used in the motor vehicles industry. These new processes, however, are expected to be used increasingly in machining of hard metals—applications usually uneconomical and often impossible by conventional processes. Electrical discharge machining, which can maintain extremely close tolerances, is being used in making tools and dies. Much of the costly and time-consuming hand labor now required is eliminated and tooling lead time is reduced substantially. Because of the higher metal removal rates possible with electrochemical machining, this process is being introduced for repetitive production work.

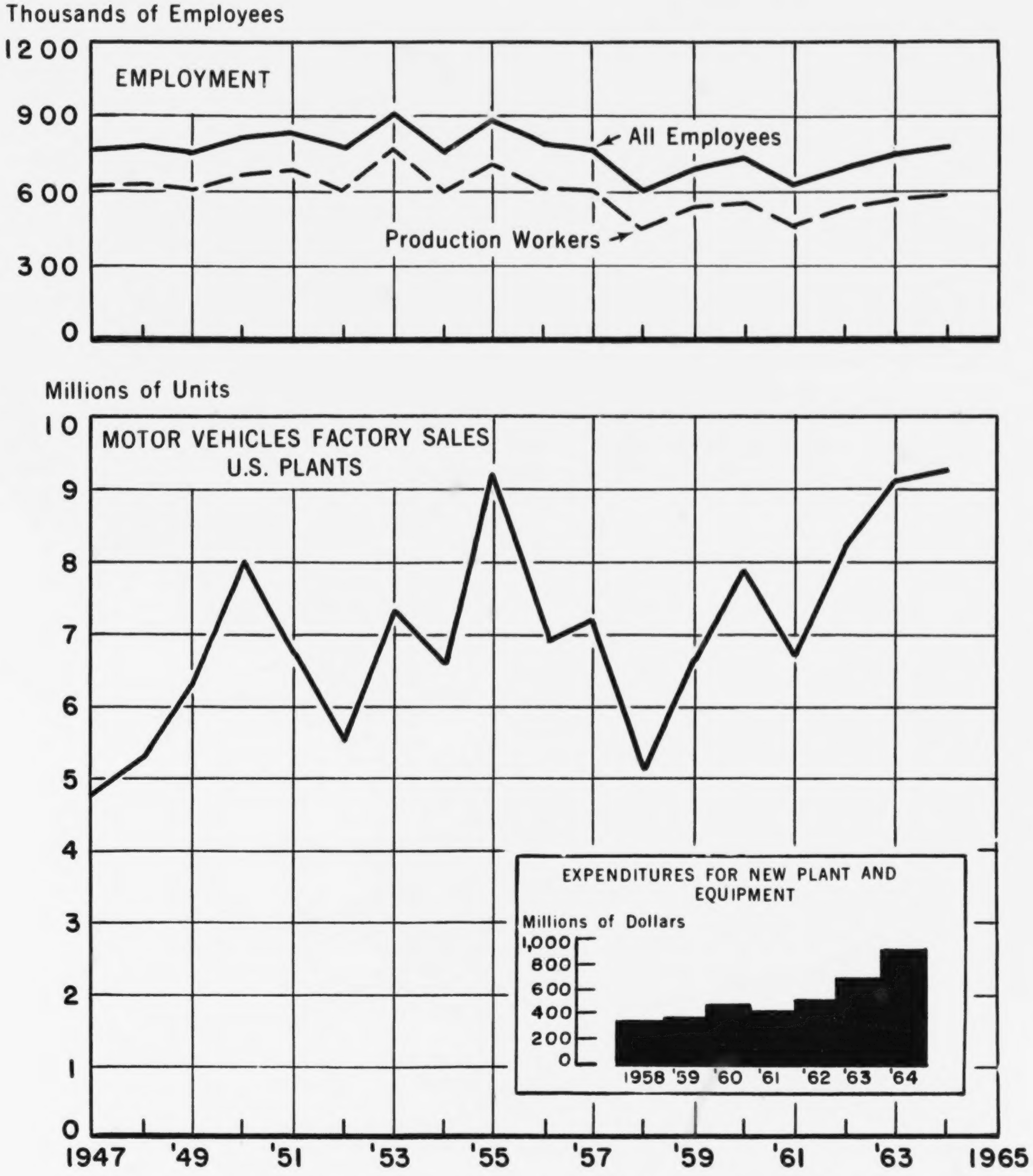
Improved techniques and equipment are continuing to be introduced into various production operations to reduce unit labor requirements. These include, among others, simplified redesign of parts, centralized monitoring of painting operations, improved materials handling equipment, more advanced automatic grinding machines, automatic spotwelding machines, ultrasonic inspection equipment, and shift from hot forming to cold extrusion. Adoption of quick die-change stamping presses, for example, eliminates at least one-half the time and expense of the former manual method of removing, installing, and aligning dies when changing the part produced.

Growing use of machines for assembly of mass-produced parts may reduce man-hour requirements. Although still quite limited, machines which can perform automatically such operations as screwdriving, nut running, riveting, feeding, and aligning are being used increasingly for the assembly of mass produced parts. The majority of assembly machines have combined mechanical and manual operations, the more complex operations still being performed by hand. Complete automatic assembly is also being developed, but its application is expected to be economically feasible for only a small number of parts. Advantages of mechanized assembly include improved product quality, increased speed of output, and reduction both in inventories and in man-hour requirements. For example, introduction of a machine which, with one operator, produces automatically 3 million piston-rod assemblies a year replaced a 20-man assembly line in one plant.

In contrast, assembly of major components and final assembly of motor vehicles—already highly conveyorized and utilizing many hand power tools—are expected to remain largely manual operations. The growing number of models and accessory options tends to limit the economic and technical feasibility of mechanizing these operations further. However, more efficient assembly is being achieved by use of computers for quality control, and for regulating the delivery and movement of parts to work stations on the conveyorized assembly line.

New materials are expected to play an increasing role in changing technology. While ferrous castings and steel remain the most abundantly used materials in motor vehicles, manufacturers are constantly introducing substitute materials to improve quality, functional, or styling requirements, or to reduce costs. Aluminum die castings and extrusions, requiring less costly and fewer processing operations, are being used

EMPLOYMENT, FACTORY SALES, AND CAPITAL EXPENDITURES IN MOTOR VEHICLES AND EQUIPMENT



Sources: Employment, Bureau of Labor Statistics; motor vehicle factory sales, U.S. plants, Automobile Manufacturers Association; expenditures, Bureau of the Census.

increasingly for numerous motor vehicle parts such as trim moldings, gear housings, grilles, and the engine block for one car model. Plastics also are gaining rapidly in use for many parts. Injection molded plastic instrument panel assemblies, replacing die cast metal panel assemblies, provide such advantages as lower tooling costs, weight savings of up to 80 percent, and elimination of many finishing operations. Parts such as crankshafts and connecting rods, long produced only as steel forgings, are now being cast successfully in nodular iron—enabling reductions in cost of materials and processing.

Search for new techniques in design and engineering provides areas of intense development. In an effort to cut lead time between design conception and production (now 2 to 3 years for a new car model), automobile manufacturers are already using computers widely for calculation of engineering data and are experimenting with a limited number of numerically controlled drafting machines. These machines, automatically operated by tape containing instructions prepared by a computer, produce engineering drawings significantly faster than can be done by draftsmen. In addition, computerized systems automating the entire engineering-design function are also in the experimental stage. For example, clay model data pickups using light or laser scanning, and digitizing sketches (translating into numbers) via cathode ray tube are among the more publicized and advanced computer input techniques being developed. These systems may enable rapid modifications of design and conversion of design data into taped instructions to operate numerically controlled drafting machines and machine tools automatically.

Computers are being used widely for data processing. According to a 1965 McGraw-Hill survey of large companies in major industries, all motor vehicle and parts companies responding reported at least one computer installation, giving a total of 382 computers. Major applications included accounting, payrolls, inventory control, production planning, and scientific and engineering applications. Over 90 percent of the companies reported plans to expand computer operations.

Research and development expenditures are expected to increase substantially. Expenditures for R&D in the motor vehicles and other transportation equipment industries—excluding aircraft and missiles—were $1.1 billion in 1963, rising steadily each year from a level of $700 million in 1957. (These are National Science Foundation data and the major portion of these expenditures is attributed, in the same source, to the motor vehicle industry.) A McGraw-Hill survey projects continuing increases up to a $1.4 billion total for 1968.

Areas of research include numerical control techniques for design engineering and manufacturing; programed manipulators to handle parts in, out, and between machines; process control systems; laser welding; new bonding adhesives, and expansion sheet-metal forming.

An important program is the continuing development of conventional and new engines for trucks, buses, and automobiles, such as the turbine engine, Sterling thermal engine, and Wankel engine. Some industry sources predict a limited number of turbine powered motor vehicles available for sale in the early 1970's. Introduction of the turbine engine—which is air cooled, requires a simple electrical system using one sparkplug, and contains 80 percent fewer moving parts than a conventional reciprocating engine—may have significant implications for manpower requirements, skills, manufacturing methods, engine maintenance, and repair.

Substantial gains in investment for plant and equipment are anticipated. In 1964, expenditures for new plant and equipment amounted to $940 million, rising irregularly from a level of $344 million in 1958. Motor vehicle manufacturers are engaged in a major program of capital expenditures to modernize existing plants and build new production facilities. A McGraw-Hill survey of investment plans indicated a continuing high level of spending through 1968. Major emphasis is to be on construction of new plant capacity.

Manpower Trends and Outlook

Employment levels for 1970 depend largely on projected demand, estimates of which vary

	Average annual percent change
All employees	
1947–57	0.02
1957–64	–.3
Production workers	
1947–57	–.4
1957–64	–.5
Motor vehicle factory sales, U.S. plants	
1947–57	4.2
1957–64	3.7

widely. Between 1961 and 1964, total employment grew from 632,300 to 755,400, and continued to increase to 846,900 in the first 6 months of 1965. In the preceding period, 1947 to 1961, total employment followed an irregular course reaching a peak of 917,300 in 1953 and a low of 606,500 in 1958. Production worker employment also reached its peak in 1953, low in 1958, and has been growing steadily since 1961.

Future employment trends will depend largely on the changes in demand as well as on the effects of improved technology. If production of automobiles in 1970 reaches only the lower prediction of 9 million units, employment will then be lower than the anticipated level for 1965. If the higher predicted level of output is achieved (12.5 million automobiles), employment in 1970 may exceed the 1965 employment level.

Occupational structure is expected to continue to change. The ratio of production workers to total employment declined from 82 percent in 1947 to a low of 75 percent in 1958, and then increased to 77 percent in 1964. Employment of engineers, designers, draftsmen, and technicians is increasing as research, development, design, and engineering functions are enlarged. Between 1950 and 1960, these occupations (according to Census data) increased by more than 70 percent. The future rate of growth of these occupations, however, may decline as drafting machines and computer assisted systems are introduced. Employment of programers, systems analysts, and computer operators may increase.

Among production workers, further use of numerical control and electronic machining will probably affect adversely the employment opportunities of such highly skilled occupations as machinist, tool-die maker, and pattern-model maker. The sizable occupation of welders, accounting for about 5 percent of total employment in 1960, may also be affected by introduction of automatic welding techniques. Increasing emphasis on efficiency of final assembly and mechanization of part assembly probably will reduce the demand for assemblers—the largest single occupational group, comprising about 12 percent of total employment in 1960. Laborers, declining by over 30 percent between 1950 and 1960, are expected to continue to decrease in number with increasing mechanization, particularly of materials handling functions.

Some Issues and Examples of Adjustment

Early retirement programs are expected to open up some job opportunities. An agreement negotiated by a major union and three large motor vehicle firms in 1964 was designed to encourage early retirement of long-service workers by reducing the age at which full retirement benefits could be obtained, from 65 to 62, and increasing pensions by more than 50 percent. Moreover, this agreement provides for substantial supplementary payments to workers with 10 or more years of service who retire between the ages of 60 and 65, and to those between ages 55 and 60 whose age plus years of service equals at least 85. These supplemental benefits are payable until the age of 65, at which time they are dropped and the worker receives the basic pension and social security benefits. It is expected that a substantial number of the estimated 30,000 workers eligible for this plan will be induced to retire before the age of 65, opening up some jobs and making possible advancement for younger workers.

Supplemental unemployment benefits (SUB) and separation pay provide continuing income for employees laid off. All major labor-management agreements provide supplementary unemployment benefits (as well as hospital, surgical, and medical benefits) up to 52 weeks to workers who are temporarily laid off because of reduction in force, plant closings, or shutdown of specific operations. Workers who are laid off for a continuous period of at least 12 months are entitled to a lump-sum separation payment, based on length of service and rate of pay. This benefit, however, is reduced by the amount of SUB and other company-financed benefits a worker may have received.

Major labor-management contracts provide greater worker job security in plant closings and other changes. Provisions include the right of a worker whose job is discontinued to transfer to any job he can perform within the plant, and with preferential rights to transfer to jobs at any other company plant within a specific geographic area. If work is transferred to another plant, employees have the right to request transfer to the new plant, retaining full seniority, and to receive a relocation allowance when the plants are at least 50 miles apart.

Selected References

Technological Developments

Carroll, William. *Automotive Gas Turbines,* Coda Publications, 1963. 120 pp.

"Computers Speed the Design Cycle," *Business Week,* Nov. 7, 1964, pp. 134–136.

Emerson, Charles. "A Primer on Automatic Assembly," *American Machinist,* Feb. 15, 1965, pp. 83–98.

Geschelin, Joseph. "Major Engineering Trends," *Automotive Industries,* May 15, 1965, pp. 73–74.

Gomolak, Louis S. "Better and Faster Design by Machine," *Electronics,* June 1, 1964, pp. 64–71.

Katke, Marvin L. "The Challenge and Opportunity of Manufacturing," *Automotive Industries,* Feb. 1, 1965, pp. 19–21.

Machinery, December 1964 (Annual Automotive Production Number). 244 pp.

Outlook for Numerical Control of Machine Tools (BLS Bulletin 1437, 1965), 63 pp.

Manpower Trends and Adjustments

Bluestone, Irving. "Automation, Collective Bargaining and Beyond," Paper presented to the Conference on the Manpower Implications of Automation, Dec. 8–10, 1964, Organization for Economic Co-Operation and Development, Washington.

Case Studies of Displaced Workers (BLS Bulletin 1408, 1964), pp. 23–46.

Denise, Malcolm L. "Impact of Automation on Employment," *Hearings Before the Subcommittee on Unemployment and the Impact of Automation,* of the Committee on Education and Labor, House of Representatives, 87th Cong., 1st sess., Washington, March and April 1961, pp. 509–574.

"Early Retirement Plan Scores Big," *Business Week,* May 22, 1965, pp. 166, 168.

Weber, Arnold R. "The Interplant Transfer of Displaced Employees," *Adjusting to Technological Change,* Somers, G. G.; Cushman, E. L.; and Weinberg, N., editors, Harper and Row, 1963, pp. 95–142.

The Aircraft, and Missiles and Space Vehicles Industries (SIC 372, 192)

Summary of Outlook Through 1970

A wide range of advances in metalworking technology are expected, including the continuing development of new space program materials and the equipment and techniques for utilizing them in fabrication, such as new forming, joining, and metal removal methods. The use of numerical control techniques is expected to increase.

While the level of employment in the aircraft and missiles industry has fluctuated widely over the past 10 years, the 1970 employment level is expected to be near or slightly below the 1964 level. Substantial changes in defense and space program budgets, however, could alter the prospects. Increases in the number of scientists, engineers, and skilled workers are expected. Extensive training and retraining programs will continue to accommodate technological changes.

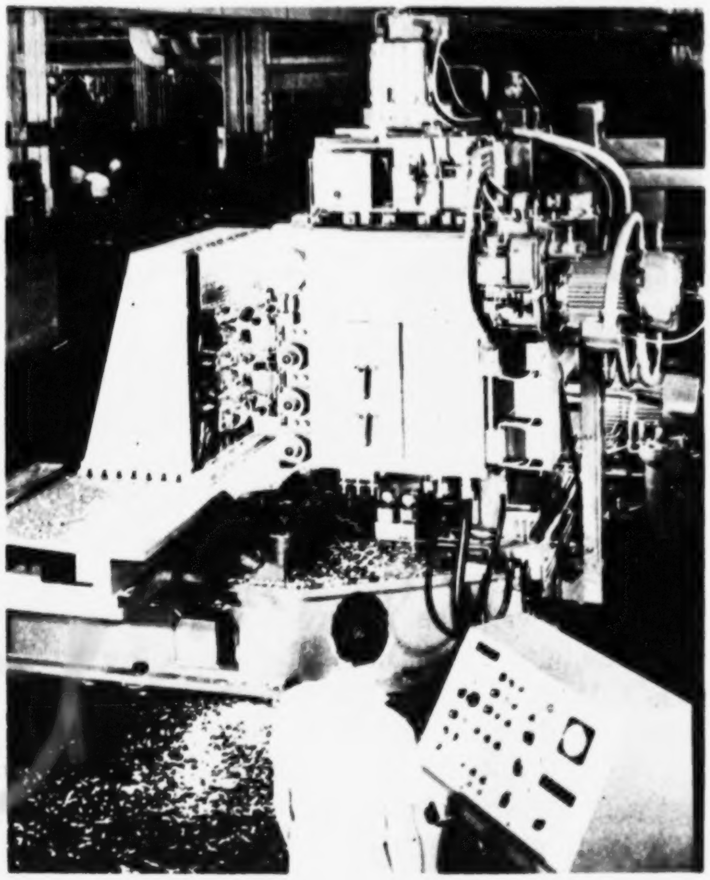
Outlook for Technology and Markets

Growth in industry's output is likely to be limited. Aircraft production, in decline between 1957 and 1963, rose in 1964 and is expected to be slightly higher than the 1964 level in 1970. The upturn in aircraft production is due largely to aeronautical developments which have resulted in extensive programs for reequipment of the Military Air Transport Service and civilian airlines with new jet planes and to the availability of jet-powered planes and helicopters for general aviation markets. Major types of aircraft which may add to production during the 1965–75 decade include the supersonic transport, a supersized cargo transport with a passenger transport version, and possibly a vertical lift transport.

Missile production, especially strategic missiles, is expected to continue declining. Some growth is expected in the production of space vehicles and systems, although the number of large space vehicles is not likely to increase beyond the presently planned levels for 1969. Although the space program is largely research and development, a few custom made vehicles and supporting ground facilities and equipment will be produced.

Increases in research and development activity are expected to continue. The aircraft and missiles industry embraces one of the world's largest concentrations of R&D activities. In addition to R&D related to commodity production, a growing and substantial proportion of the industry's sales consists of receipts from government agencies for R&D services only. According to the National Science Foundation, R&D expenditures in these categories for 1963 ($4.8 billion) were almost double those for 1957, and constituted 38 percent of total United States R&D expenditure, compared with 32 percent in 1957.

Continuing expansion of the space program is expected to cause an increase in R&D expenditures relative to total production. One organization has predicted that by 1969, the industry's



Machine tool operator monitors a numerically controlled milling machine.

R&D budget will be 60 percent greater than its production budget. The same organization estimated that for 1963 the production and R&D budgets were about equal.

Demand for new space vehicles and more powerful means of propulsion, the need for developing new equipment to do jobs already programed, and the hazard to humans of the space environment make research, development, and testing increasingly important to the industry. Testing the properties of new materials, the performance of subsystems and systems, and structural and environmental testing, including simulation of complete outerspace environments, are examples of industry research activities. In addition, research, development, and testing of manned aircraft of the future, such as vertical take-off and landing craft, and supersonic and hypersonic transports seem likely to increase in the next few years.

Expenditures for new plant and equipment reflect the changing nature of the industry. Between 1954 and 1963, expenditures for new plant and equipment by 16 major aircraft companies totaled more than $2 billion. A peak of plant and equipment expenditures in 1957 reflected emphasis on missile production. Capital spending declined after 1957, but rose to another peak in 1963, with the increase in expenditures for the space program. Almost all the new facilities were reported to have been for R&D programs. Investment in highly specialized facilities is expected to continue.

New manufacturing operations increasingly involve materials that can withstand extreme temperatures, pressures and stresses. The skin of a Mach 3 supersonic plane reaches an average temperature of about 600°F in flight; turbine inlet gas temperatures reach 2,000 to 2,500°F., and loads on turbine buckets reach 18,000 psi. For space vehicles, where speeds of reentry reach 25,000 m.p.h., demands are still greater. It is estimated that by 1975, combustion temperatures of rocket engines will reach 6,000°F.

Likely developments, therefore, include new methods of using titanium because of its ability to withstand extremely high temperatures and its high strength-to-weight ratio. Refractory metals such as columbium, molybdenum, and tantalum probably will not be used much before 1980. New alloys of these metals and composite substances, such as metals and plastics, metals and ceramics, ceramics and plastics, are being developed. Aluminum and magnesium alloys are expected to remain the basic structural materials of subsonic vehicles, launch vehicles, and the internal cores of many advanced models.

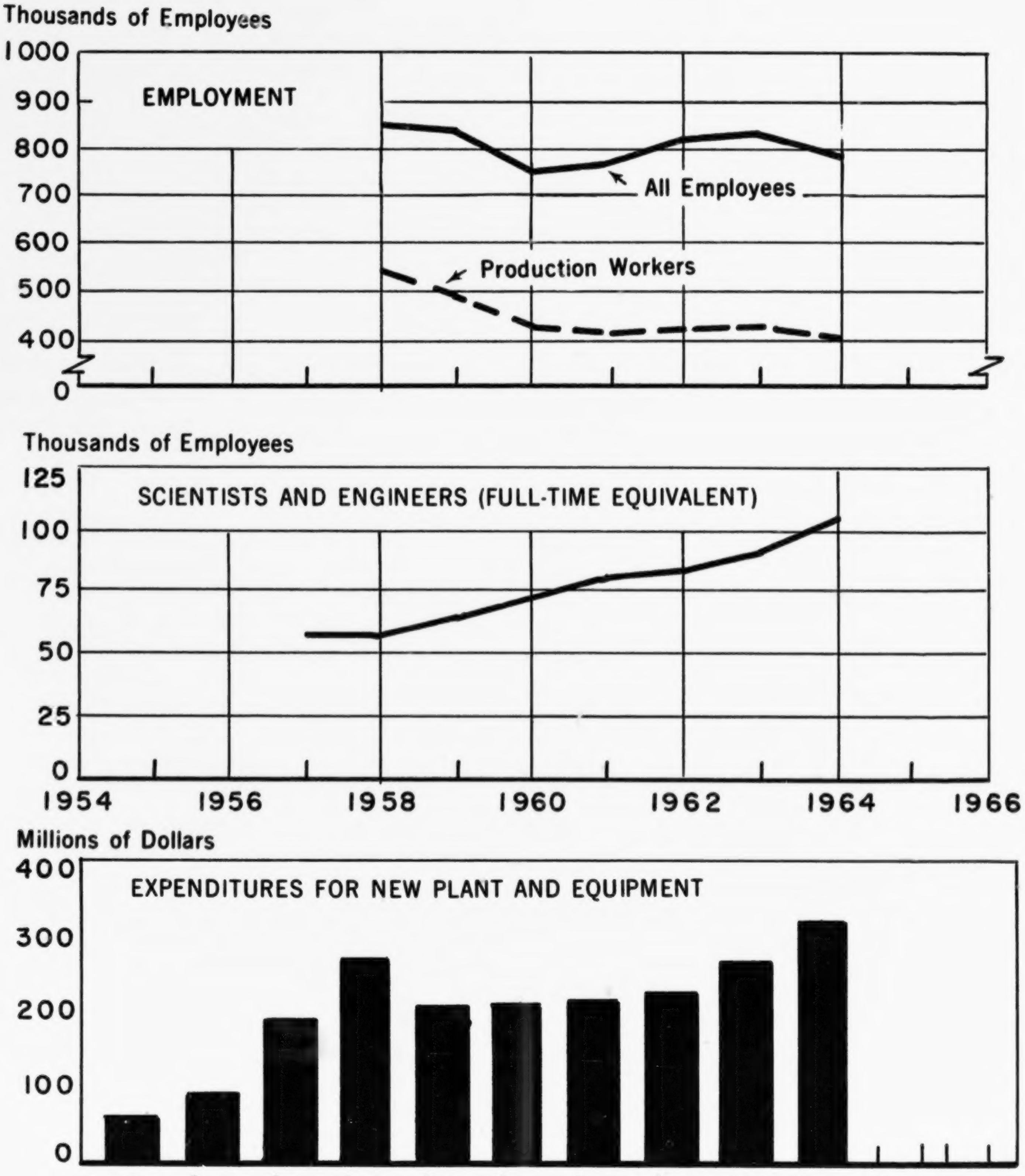
Titanium is of most interest currently for rockets and space vehicles. Titanium, super alloys, and refractory alloys will receive preference as primary structural materials for supersonic and hypersonic vehicles. Reinforced plastics will probably be used for secondary structures, hot gas ducts, heat shields, radome walls, rocket motor cases and nozzles, and plastic foams for thermal protection of all kinds.

New methods of fabrication are being used on new materials. New manufacturing techniques and specially designed equipment are used to work the new materials; in some cases, because these materials are extremely hard and do not lend themselves to fabrication by conventional means; in other cases, because new materials with high mechanical strength are best employed in built-up structures using extremely thin gage sheet. Metal forming and joining of the new materials are expected to grow at the expense of machining. Many products will be made in final form in which machining is not necessary.

More advanced methods of metal forming evolve as use of the technique increases. According to forecasts made by experts for the Aerospace Industries Association (AIA), metal forming may rise from about 25 percent of fabrication costs in 1964 to about 35 percent in 1975 because of extensive use of sheet metals in space vehicles. New forming methods include high temperature and subzero forming, forming at high energy rates, powder metallurgy, filament winding, etc. Some of these methods are said to require further development before extensive capital outlays can be justified.

High temperature forming (over 600°F.) will be necessary for titanium, refractory metals, and other high strength alloys. Medium and high pressure presses (2,000 to 200,000 psi), capable of exerting higher pressures over

EMPLOYMENT AND CAPITAL EXPENDITURES IN THE AIRCRAFT, AND MISSILES AND SPACE VEHICLES INDUSTRIES



Sources: Employment, Bureau of Labor Statistics; scientists and engineers, National Science Foundation; expenditures, from an Arthur D. Little, survey of 16 major companies.

larger areas, may become more important. More chemical explosive forming may be used for exceptionally large parts. Conventional bulging methods will be increasingly improved. Capacitor discharge forming is rapidly becoming a competitive metal forming method and may make feasible operations formerly considered impossible. Portability and flexibility of capacitor discharge equipment will permit on-site or in-position forming of parts which previously required removal to shop areas. The capability of the equipment to form large articles is improving at a very rapid rate.

Welding is expected to increase as joining becomes more important. In 1964, welding and brazing are claimed to have accounted for about 12 percent of the fabrication costs of aerospace systems and 30 percent of all joining operations. The operation is expected to account for about 28 percent of fabrication costs and 60 percent of joining operations by 1975, according to AIA experts. Electron beam or laser welding is expected to rise from 1 to 28 percent of all welding. Diffusion bonding, a method of welding metals of dissimilar properties and now negligible, is expected to rise to 10 percent. Frequently, these new methods are used because small quantity production does not warrant the use of older, high quantity methods. Adhesive bonding will be used to fasten ablative and insulating materials to structural members, to bond composite structures, and in bonding insulating materials themselves. Mechanical fastening is expected to fall from around 60 percent to 30 percent of joining.

Metal removal is expected to decline relative to other fabricating techniques. Despite improvements in conventional machine tools and rapid development of new processes, AIA experts expect metal removal to decline from about 63 percent of total fabrication costs in 1965, to about 37 percent in 1975. Current research is designed to improve conventional cutting tools, adaptive controls, tool vibration control, methods of automatic setup, and computer aided design. New processes expected to become increasingly important in metal removal include chemical milling, electrical discharge and ultrasonic machining, and machining by electron beams, lasers, and other newly developed methods. Many products may be made in final form in which machining will not be necessary.

Numerical control processes are expected to expand to all phases of manufacturing. Changes in work requirements, towards greater complexity and closer precision, as well as wider product diversity, smaller sized lots, and more frequent engineering changes, tend to increase the need for numerical control. In 1964, more than 600 numerical control tools were in use in the industry. AIA experts expect more than 1,600 by 1975.

Early emphasis of numerical control (N/C) equipment was on contour type machines, but the greatest future growth is expected in positional applications and combination and multipurpose type machines. Entirely new types of machines which are anticipated include tube benders, lofting, drafting, and dimensional inspection machines. Several new types of numerical control processes are also anticipated.

Computer programing of numerical control tools is expected to increase and in many cases the tape will be a direct computer input to the machine. Major cost reductions are expected from a universal programing system developed cooperatively by the aerospace industry under sponsorship of the Aerospace Industries Association, which reduces setup time for all numerical control tools to a fraction of the time previously required. Numerical control tools already reduce unit labor requirements by an estimated 20 to 80 percent, depending on the application.

Because one N/C tool displaces more than one conventional machine tool, the total number of machine tools is likely to be reduced. By 1975, the number of tools in the inventory is expected to decline substantially while the value of the stock of tools remains constant—reflecting the high productivity of modern tools.

Plastics and ceramics fabrication. In general, ceramics and plastics are formed by high temperature and/or high pressure methods. As some of these materials are forced to meet design specifications at 4,000°F. or higher, fabricating temperatures and pressures are likely to go higher. Some ceramics processing techniques now in rudimentary use which need additional development include hot pressing, isostatic pressing, vapor deposition, plastic air spraying, and filament winding.

Use of computers is expected to expand. According to a 1965 McGraw-Hill survey on the use of computers, all aerospace companies in their sample use computers for accounting, inventory control, and production and planning control. Ninety-two percent of the companies use them in management science, and in scientific and engineering applications; 69 percent in data acquisition; 54 percent in business forecasting; and 31 percent in location selection or for other purposes. Almost one-half of the firms use computers in production line operations. Nearly all of the firms believed their computers had performed as well as or better than expected and were planning to include additional applications.

Manpower Trends and Outlook

Employment in 1970 may be only slightly below the 1964 level. Between 1958 and 1960, employment in aircraft (SIC 372) and missiles and space vehicles (SIC 192) declined from 848,100 to 765,100, reflecting the decline in aircraft production. After 1961, these industries were becoming increasingly involved in the missile and space program with a resultant rise in employment to 833,600 in 1963. With deemphasis of missile production, employment declined to 790,600 in 1964, and in 1970 may be only slightly below the 1964 level.

Structural composition of the work force may continue to change. Between 1958 and 1964, production workers in aircraft and missiles declined from 526,300, or 62 percent of the work force, to 407,000, 51 percent of the total. Production workers are expected to remain at about 50 percent of total employment. Over the same period, the number of scientists and engineers rose from 59,000, or 18 percent, to 106,000, or 28 percent of the industry's nonproduction workers. This proportion is expected to increase. The National Science Foundation projects industry scientist and engineer employment in aircraft and missiles to reach 195,000 by 1970; requirements for research technicians are projected to rise from 49,000 to 107,000.

	Average annual percent change
All employees	
1958–64	−1.2
Production workers	
1958–64	−4.2
Scientists and engineers	
1957–64	8.8

Some Issues and Examples of Adjustments

Companies provide training to relieve skill shortages. In the shift to space technology, many aircraft companies had to undertake extensive education and training programs. Training was given both in-plant and at educational institutions for all types of employees; factory, office, semiprofessional, managerial, and engineering. Many companies continue in-plant retraining of workers whose jobs have been eliminated by technological change. Many workers, therefore, have learned by retraining to perform tasks such as plasma welding, chemical milling, and electrical discharge machining, little known until recently.

However, shortages of skilled and professional workers have continued to exist. Shortages are particularly acute for physicists, mathematicians, and electrical, mechanical, and aeronautical engineers. Some companies report shortages of skilled production workers such as draftsmen, machinists, tool and die makers, and electronic technicians.

U.S. Government training programs supplement those of aircraft and missile companies. Training programs under the Manpower Development and Training Act of 1962 are relieving shortages of basic skills. A single aircraft plant placed 494 persons out of 626 trained in basic machine shop operations, template, and tool and die making. Other courses given specifically for the aerospace industry are microminiaturization, arc welding, and electronic mechanics.

State employment services aid industry and displaced workers. In addition to interarea recruiting, counseling, testing, and initiating training programs, State employment agencies are conducting research designed to maximize the utilization of skilled aerospace workers who have been displaced. In Washington State, for example, the State employment agency, under contract with the U.S. Department of Defense, has conducted a study of the effect of the "Dyna-Soar" contract cancellation on employees in the Seattle area. Similarly, the New York State Department of Labor has undertaken a study of aerospace employees laid off in the Nassau-Suffolk area.

Hiring practices and severance pay plans reflect the tendency toward short-term fluctuations in employment. Sudden contract terminations result in frequent periods of unemployment for some workers. Companies receiving additional contracts, however, customarily offer employment to workers laid off by other companies.

A few companies have severance pay plans under collective bargaining agreements which provide payments dependent on absolute termination and length of service. More prevalent, however, is the "extended layoff benefit plan," which differs from traditional plans largely in that the employee need not be terminated to receive payments and there is no explicit statement of termination. The employee receives a lump-sum payment which supplements State unemployment benefits, but retains job seniority, accrued vacation and sick leave, and insurance benefit coverage, for an indeterminate period.

Planned expansion in other markets may offset possible declining domestic defense requirements. Special industry committees have been formed to boost U.S. participation in a multibillion dollar new equipment program of Allied Nations, to facilitate the continued conversion from a production oriented technology to one that is research oriented, and to create conditions permitting application of skills acquired in systems research toward solution of other major national problems. In California, for example, aerospace companies are assisting in the solution of such diverse and difficult problems as integrated transportation systems, air and water pollution control, worker retraining, crime control, and the desalinization of sea water.

Selected References

"Aerospace Economics," *Aerospace,* June 1963, pp. 2–11. Stanford Research Institute.

Aerospace Employment, Labor Market Reports 102, 105, 111, 112. U.S. Department of Labor, Bureau of Employment Security, Washington.

Aerospace Facts and Figures, Aerospace Industries of America, Washington, 1964.

Aerospace Industries of America, *Annual Report, 1963.*

Aerospace–Technical Forecast, 1962–1972, Aerospace Industries Association of America, Inc., Washington.

Brown, Edmund G. "New Dimensions for Aerospace Technology," *Aerospace,* spring 1965, pp. 6–9.

Davis, Lt. Gen. W. Austin. "Trends in Aerospace Technology," *The Sperryscope,* First Quarter 1965.

DMS, Inc. *Aerospace,* FY 1966–70, New Haven, Conn., 1965.

"Fewer, Better Machine Tools," *American Machinist,* July 5, 1965, pp. 80–82.

Miller, Thomas G. Jr. *Strategies for Survival in the Aerospace Industries,* Arthur D. Little, Inc., 1964.

The Industry-Government Aerospace Relationship, Stanford Research Institute, Menlo Park, Calif., May 1963.

The Instruments and Related Products Industry (SIC 38)

Summary of Outlook Through 1970

Product innovation, including development of instruments of greater accuracy and reliability, smaller size, and increased sensitivity, probably will continue to be the principal area of advancing technology. Instrument makers also are expected to give increasing attention to the use of labor saving techniques, such as numerical control, in their manufacturing operations. Increases in instrument output and employment are anticipated through 1970, in response to increasing market demand due to greater industrial automation, growth of research and development, and expansion of space and defense programs.

Outlook for Technology and Markets

Rapid growth in output is expected to continue. The Federal Reserve Board index for instruments and related products (SIC 38) advanced at an average annual rate of 6.2 percent between 1947 and 1957 and at the lower rate of 4.8 percent between 1957 and 1964, but still above the growth rate for manufacturing. For the diverse industries within the industry group, however, growth trends vary markedly, reflecting differing market demands and rates of technological innovation. Production of scientific, industrial, and technical instruments has been increasing consistently throughout the entire 1947–64 period, at a considerably higher rate than that for the group as a whole. Output of surgical, medical, and dental instruments, increased relatively more slowly and the domestic output of watches and clocks declined.

Many developments point to an increasing demand for instruments: Continuing high levels of spending for space and defense programs, rapid growth of civil aviation and increasing complexity of air traffic control and navigation facilities, expected growth of the continuous-process industries, greater industrial automation, expanding medical care programs, and increased spending for research and development in such fields as oceanography and medicine. The proposed conversion of U.S. scientific measurement to the metric system would expand the market for instruments.

Some of the expected new demand for instruments during the remainder of the decade will probably be centered in industries specializing in producing electronic instruments and may not be reflected in data for this industry.

New markets for industrial instrumentation will offer greatest growth potential. Most rapid growth is expected from industries in early stages of automation, such as mining, transportation, and batch-type manufacturing industries, including nonferrous metals, iron and steel, water and waste treatment, control of air pollution, and stone, clay, and glass products. Capital spending in these industries is expected to increase rapidly and the portion applicable to instrumentation even more rapidly. Continuous-process industries, which have long been the largest volume market for instruments, are expected to remain so at least until 1970. A trade publication survey of 60 large instru-

Magnifying up to 100,000 times, the electron microscope is used to aid scientific and industrial research.

ment-using companies indicated that by 1975, 10 to 15 percent of their total spending for plant and equipment would be for instrumentation, as compared with mid-1965 averages of 3 to 5 percent. Some companies already were spending 10 percent.

Product innovation is expected to remain the most important aspect of technological development. Product innovation will mean continued improvement of existing instruments and the development of complete new families of instruments. Improvements in existing instruments include smaller size, wider sensitivity ranges, increased ruggedness, improved resolution in optical instruments, and better stability in electrical and electronic instruments. Modern electron microscopes, for example, have improved vacuum and higher resolving power. The reliability of oscilloscopes is increasing, while power requirements and size are being reduced.

New instrument families include radiation detection, measuring and utilization instruments, infrared sensing instruments, and ultraviolet detecting and analytical apparatus, ultrasonic detection instruments, a range of new optical instruments associated with laser technology, and instrumentation for advanced space research. Newly developed nuclear magnetic resonance instruments can identify and characterize organic molecules. Increasing use is made of nuclear techniques, such as those involved in oil well logging, thickness and density measurement with nuclear gages, the measurement of ground, air, and water contamination, neutron activation analysis, and in nondestructive testing with radioisotopes. The trend towards more complex and multipurpose instruments, greater miniaturization, increasing precision, and an increased demand for integrated control systems is expected to continue.

Important product innovations are occurring in photographic equipment and supplies. Included are: instant picture processes and equipment, self-loading and modular cameras, totally new concepts such as "holograms," improved infrared photographic devices and film, and the development of nonsilver, light sensitive materials and equipment for using them. The latter have proved valuable in the reproduction of office documents and engineering drawings; future opportunities are said to exist in image retrieval systems, data storage, transmission and retrieval, commercial printing, etc. Fiber optics, a technique of bending light rays for photographic and lighting purposes, television and other optical applications, is a laboratory development expected to have wide application in the future.

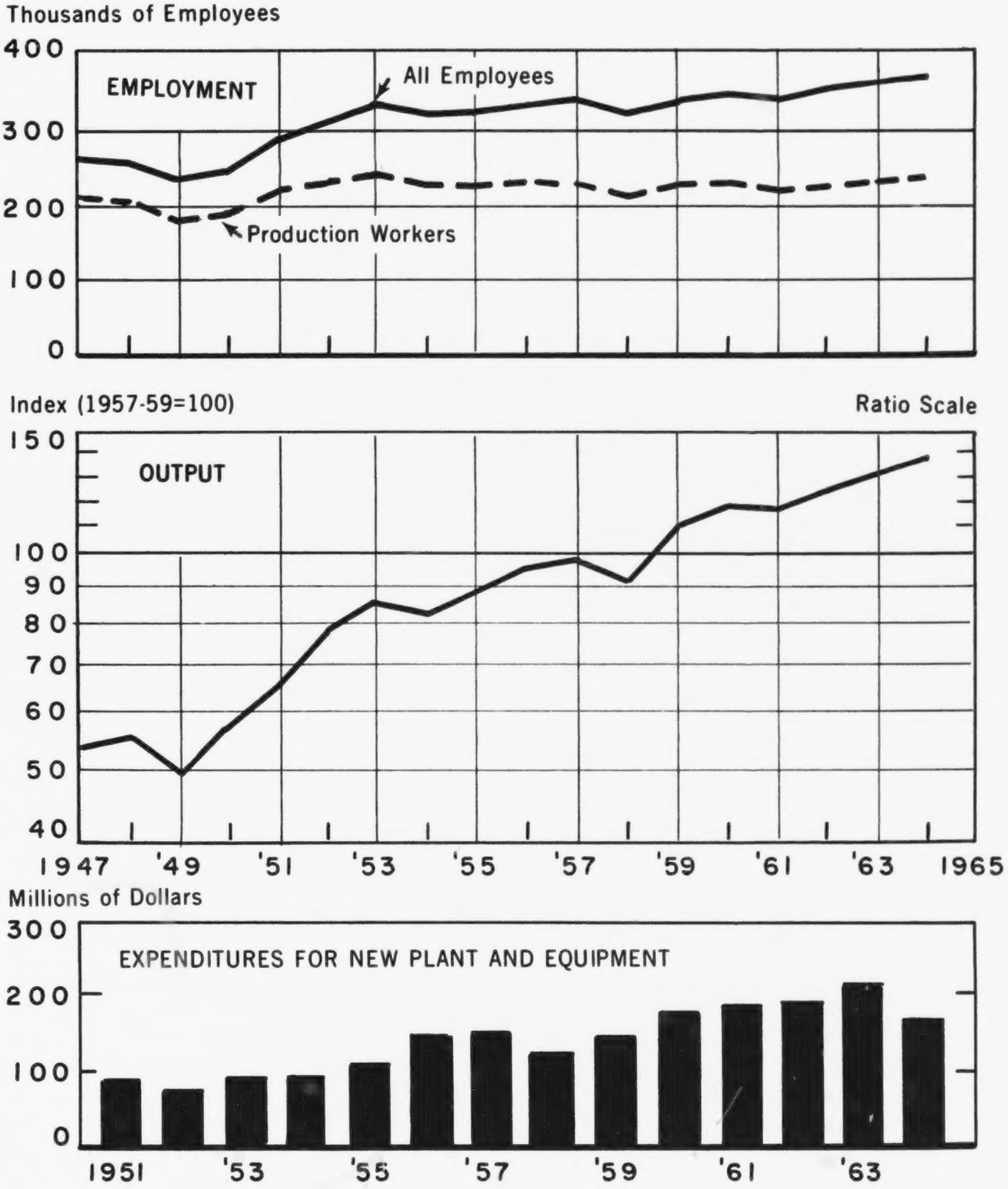
Industry is endeavoring to improve fabrication methods. Instrument makers are expected to direct increasing attention to the application of labor saving techniques in their own operations; however, instrument manufacture is characterized by short production runs of specialized and varying products, and frequent design changes which make the application of automatic production methods difficult. These methods may be used increasingly in fabricating stages, but assembly, balancing, and calibration remain largely manual operations. Some items, for which automatic equipment technically could be used, often are produced in insufficient volume to justify the cost of the equipment.

Numerically controlled machine tools, notable for increasing efficiency in job lot production, are being used in instrument manufacturing. In 1963, 68 numerically controlled tools were in use and the number was increasing. Numerically controlled machine tools reduce per unit setup time associated with the use of conventional machine tools.

The practice of using high strength adhesives to assemble instruments and parts is increasing. The use of transfer devices, including conveyor systems, is growing and more products are being designed for portability and ease of handling in manufacturing.

Makers of specialized instruments are improving production processes. The availability of precision mechanical components for optical equipment, for example, reduces the need for highly skilled instrument makers in the process of centering the optical and mechanical axes of the instruments. Assembly can now be performed at the distributors' level, permitting instruments to be shipped unassembled instead of being factory-assembled. This development allows dealers to offer greater selectivity without increased inventories.

EMPLOYMENT, OUTPUT, AND CAPITAL EXPENDITURES IN INSTRUMENTS AND RELATED PRODUCTS



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board; expenditures, Bureau of the Census.

The application of computers in solving the mathematics of optical physics and the development of low diffraction rare earth glasses are new techniques utilized to produce superior optical instruments in shorter time. Solid state techniques and the use of integrated circuits are important improvements in electronic instruments manufacturing. New numerical control processes for circuit board etching and parts insertion are being combined with automatic soldering techniques, substantially reducing assembly labor requirements. Integrated circuits eliminate many individual components and many assembly operations, offer greater reliability, smaller size, and lower power consumption.

Automatic data processing and remote data-collection systems (RDC) are being used by a few large companies. Information on completion of individual operations, such as number of parts completed and inspected, time required, and hourly wage rates, is continuously transmitted to a remotely located computer. Total inventory and costs and forecasts of completion time for the project are calculated. RDC systems are said to permit a constant check on quality and costs and to obtain maximum utilization both of men and machines. In one large company, for example, remote data-gathering equipment installed in clean rooms (sealed, pressurized, and dust free) is said to save $40,000 a year above the cost of the equipment by permitting workers to "report" without leaving the room. Remote data gathering is said to be most useful in operations involving extensive use of highly skilled labor. In reporting labor costs on jobs, a system with 10 input stations is said to replace from three to five clerks. Ultimately, RDC may be incorporated in "total management information systems" which permit similar controls of the production process from incoming orders to product shipment.

Other modern management methods in increasing usage, such as operations research, critical path analysis, and PERT (Program Evaluation and Review Technique), are facilitated by a constant flow of accurate information from remote data-gathering facilities.

The spread of quality control systems and equipment reflects demand for greater reliability. In addition to extensive testing equipment, preventive systems, such as clean rooms, air-conditioning and pressure systems are used increasingly, especially in making scientific and engineering instruments. Zero defect programs may spread to instrument manufacturing. More complete testing of each instrument part and use of assembly stations where completed instruments are tested are said to be increasing.

A rising trend in research and development is likely. Between 1956 and 1963, annual expenditures for research and development more than doubled, rising from about $200 million to nearly $500 million. Increased outlays were accompanied by a 70-percent increase in employment of scientists and engineers, from 10,200 to 17,200. Deeper involvement in production of complete systems will require increased outlays for research into widely differing industrial technologies. In addition, considerable research will probably be devoted to methods for improving their own production processes.

Capital expenditures are expected to continue rising. From an average of $96 million annually between 1949 and 1956, expenditures for new plant and equipment rose to an average of $172 million between 1957 and 1963. Increased investment is expected for additional capacity, the necessary product diversification attendant upon expanded systems technology, establishment of wide-scale service facilities, and the equipment necessary to automate more of their own functions.

Manpower Trends and Adjustments

Growth of employment will continue. Between 1947 and 1957, employment increased at an average annual rate of 2.5 percent, rising from 267,000 to 342,100. Between 1957 and 1964, the rate of growth declined to 1.1 percent compounded annually. Employment reached 369,300 employees in 1964. Despite the declining rate

	Average annual percent change
All employees	
1947–57	2.5
1957–64	1.1
Production workers	
1947–57	.9
1957–64	.1
Output	
1947–57	6.2
1957–64	4.8

of increase, employment in this industry has grown several times as fast as the average for total manufacturing during the entire postwar period and continued growth is expected. Much of the future employment arising from increased instrumentation, however, may be in electrical machinery and electronics industries, rather than in the instrument industry.

The structure of the work force is changing. Between 1947 and 1964, the industry employed an increasing proportion of nonproduction workers. Production workers declined from 80 to 63 percent of total employment.

Women workers made up a significant portion of total industry employment in 1964, ranging from 23 percent in the scientific instruments group to 57 percent in watches and clocks. Between 1959 and 1964, employment of women increased faster than total employment.

Some collective bargaining agreements contain job security provisions. Of 22 major collective bargaining agreements in effect in 1963, covering 45,400 workers, 10 agreements covering 17,400 workers incorporated provisions for severance pay or for extended layoff benefits to protect workers who were dismissed or laid off for extended periods. A few agreements also contained clauses that restricted the subcontracting of production which is customarily carried on in the plant.

Selected References

"Controls Industry," *Investor News,* Francis I. Dupont and Co., June 1964, pp. 12–18.

"Instrument Users See No Way But Up," *ISA Journal,* January 1965, pp. 18, 20.

Lee, A. E. "What the Next Decade Holds for the Instrument Industry," *ISA Journal,* October 1964, pp. 69–72.

Rogers, John. "Industrial Engineering at Autonetics," *The Journal of Industrial Engineering,* January–February 1965, pp. 19–22.

Schall, W. C. "Instrumentation in the 60's: The Big Shift Has Started," *ISA Journal,* October 1964, pp. 61–68.

Sprague, P. A. "Some Reflections on Profits and Research in the Instrument Industry," *ISA Journal,* May 1964, pp. 78–84.

Byrne, Francis P. "Advances in Chemical Instrumentation," *Industrial Research,* June 1965, pp. 52–59.

Brunton, Donald C. "Advances in Radiation Instrumentation," *Industrial Research,* June 1965, pp. 77–82.

"Control Users Pinpoint the Potentials," *Control Engineering,* January 1965, pp. 77–97.

Aldridge, Keith. "The Boom is Just Beginning," *Control Engineering,* January 1965, pp. 67–70.

U.S. Bureau of the Census and Defense Services Administration. Current Industrial Reports, *Selected Instruments and Related Products,* Series M38 B(63)1, Washington, D. C., 1965.

The Meat Products Industry (SIC 201)

Summary of Outlook Through 1970

Meat consumption is expected to continue its gradual rise, stimulated both by population growth and increases in per capita consumption. Extensive improvements in handling and processing are being introduced, especially in new plants being built near areas of concentrated livestock feeding in the West. Employment may continue to decline for several years, but at a gradual rate. Shutdowns of large, obsolete packing plants have caused serious problems of worker adjustment.

Outlook for Technology and Markets

Meat production is expected to continue rising at a moderate pace. Output (excluding poultry) rose 1.7 percent a year during the 1947–57 period; 2.2 percent annually from 1957 to 1963, according to the U.S. Department of Agriculture. Beef and veal production is expected to rise most rapidly, from 17 billion pounds in 1963 to nearly 25 billion pounds by 1975; poultry production, from 7 billion pounds to over 10 billion pounds. Pork, lamb, and mutton production will rise only very slightly.

The extent of processing and fabrication within the meat products industry is gradually increasing. Demand is growing for convenience foods (e.g., frozen precooked dinners) and processed meats (e.g., sausage, frankfurters, ham, and bacon), which in 1964 totaled between one-third and one-half of all meat produced. The rapidly expanding institutional market (hotels, restaurants) demands precut, portion-controlled, ready-to-cook meats. Because of the economies of breaking meat into these final cuts on a mass basis, a growing proportion of fresh meat may be boned, defatted, and cut to standard trim either at processing plants or chain store central cutting facilities. Jobs may be shifted slowly away from the retail store, into the wholesaling or meat products industries.

Further processing of mass-produced poultry is growing. About one-quarter of all poultry is now processed into frozen dishes and similar fabricated foods, or sold as cut-up poultry parts. Increasingly greater numbers of the big (25 pounds or over) "institutional" turkeys are being processed into turkey specialties. These are killed in the fall, frozen, and then fabricated in the spring, thus reducing seasonality of employment. Rapidly growing demand for frozen, cut-up chicken, and for prepared specialty items, is increasing the amount of handling in poultry plants, which are shifting from the Midwest to the West Coast and the Southeast.

Livestock slaughtering plants are continuing to shift westward. For example, Illinois, first State in cattle slaughter in 1947, was sixth in 1964; Iowa is now first. This movement is induced by population shifts, obsolescence of multistory central city plants, increasing use of trucks, and economies of shipping carcasses, quarters, and primal cuts rather than live animals. The trend is toward specialized slaughtering and processing plants of medium size.

One of the most important technological innovations in recent years is the cattle on-the-rail dressing system first introduced a decade ago. About 65 percent of all cattle slaughter is now done in rail system plants. Most large plants employ the system, and medium-size plants are rapidly installing it. In rail systems, stunned cattle are hoisted to a high conveyor rail, on which they are slaughtered and then moved through all dressing operations to the chill cooler. Workers, stationed on mechanized platforms which move vertically and horizontally according to the requirements of each task, use power knives and saws. Mechanical hide strippers, which grasp and peel the hide from the carcass, substantially reduce the skilled hand-cutting operations once necessary to remove a high-quality hide without damage.

Laborsavings per unit may be between 25 and 60 percent on the kill line. These savings are in reduction of waiting time between performance of individual tasks, which are now machine-paced and synchronized, and elimination of constant repositioning of the carcass necessary in the older "bed" system. Part of the improvement in efficiency reflects better utilization of plant and equipment capacity because of a smoother inflow of cattle in new plants built near livestock supplies. Roughly 10,000 to 14,000 workers are engaged in cattle dressing and supporting operations prior to placing carcasses in the chill cooler.

Further mechanization is expected to reduce labor requirements in hog dressing. Continuous rail operations may be developed for slaughtering. Dehairing and shaving the carcass, and butchering operations on the hog head are affected. Automatic positioning and transfer equipment, as well as contour sensing equipment which can guide mechanized knives, may be used within a few years. A new method for smoked and fresh pork which eliminates chilling prior to cutting, currently in experimental stages, reduces processing time but requires pork butchers to acquire new cutting skills. Also, a machine which permits one worker to view each carcass on a screen and guide cutters by marking major cuts on the screen image with a pointer, is being tested.

Mechanized, continuous frankfurter-making systems are being installed rapidly. They join a series of operations which emulsify, form (or stuff and link), smoke, cook, chill, peel, wash, and fully package frankfurters. Jobs in stuffing, linking, and packaging are eliminated. Sausage and prepared chub meats may soon be handled in the same way. At the same time, trimming jobs, in the preparation of raw materials for sausage and frankfurters, are being reduced by mechanical fat separator equipment using low heat and agitation.

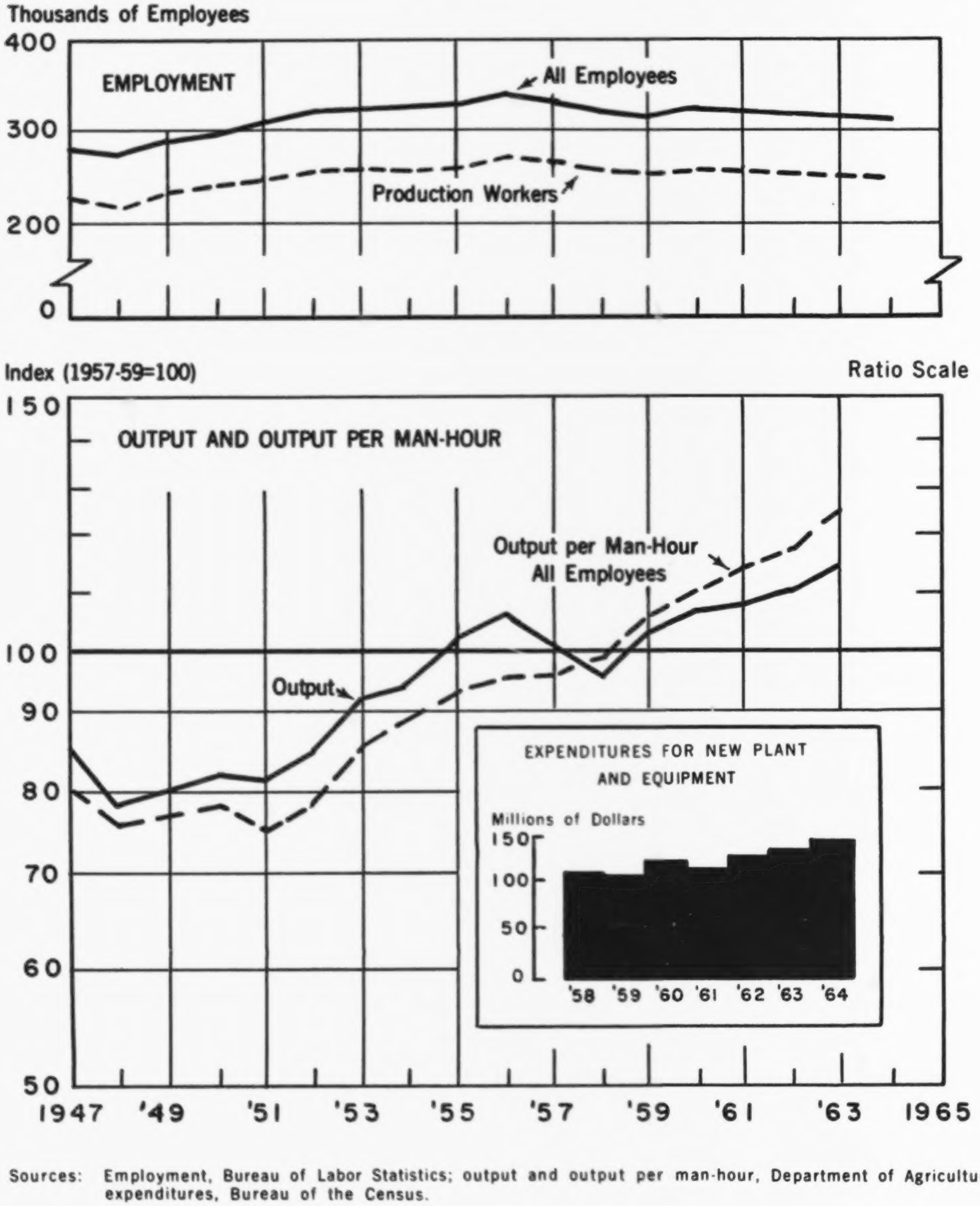
Highly mechanized rendering systems are being installed in some large meatpacking plants. About 20 percent of rendering done by the meat industry is in plants with conveyor systems (for handling raw materials and material in process, as well as finished products); crushers; and centralized control panels for all operations. New rendering systems require one-third as much labor as rendering departments which rely on manual labor for shoveling raw material, manual control of tanks, and hand flushing and cleaning. Odors from open storage and equipment make working conditions in old plants unpleasant. About 3,000 to 3,500 men work in rendering departments of meatpacking plants.

Hide processing is undergoing rapid change. The older dry salt method of curing is being replaced by brine curing; labor requirements per unit are reduced by 50 percent and processing time is reduced from 1 month to 1 or 2 days. In the past 5 years, this new method has been adopted in plants producing 80 percent of all packer-cured hides (one-third of all cured hides—the rest are cured by hide dealers).

A more advanced process (called "beaming") which eliminates curing entirely, has been installed in three meatpacking areas in conjunction with packing plants. This beam process will reduce labor requirements in hide dealers and tanneries as well, because it takes the hide one step further in the processing chain. By 1975, according to a U.S. Department of Agriculture expert, at least one-fourth of all packer-

Carcass is split as it travels on rail, by worker on moving platform.

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR ,AND CAPITAL EXPENDITURES IN MEAT PRODUCTS



Sources: Employment, Bureau of Labor Statistics; output and output per man-hour, Department of Agriculture; expenditures, Bureau of the Census.

cured hides are expected to be processed by beaming; over a quarter will be processed by brine curing. Over one-fourth of the hides will be used for products other than leather. This last category, which includes such hide products as collagen for edible sausage casing and medical sutures, is a rapidly growing outlet for raw hides.

Conveyors and mechanical equipment are being introduced in poultry dressing. For some tasks, productivity is increased 50 to 100 percent. Electronic weighing and packaging machines, continuous freezing units using liquefied gas, and mechanical defeathering that processes up to 9,000 chickens an hour, are being used. Low wage rates in poultry packing plants, and the small size of firms, are among the factors that tend to retard technological change.

New preserving techniques, such as freeze drying and irradiation, are being accepted only slowly. Irradiated bacon has been approved by the Food and Drug Administration for public sale, but is not yet commercially produced. Problems of safety, taste alteration, costs (especially with low volume production), and public acceptance of irradiated meats remain to be solved, although the Army is already beginning to use irradiated bacon in its regular rations. The chief advantage of irradiated meat is that it permits the meat to be stored for longer periods of time.

Freeze drying is already used by a few meatpacking and specialized drying plants. Products are dried meat and poultry dices for dried soups and prepared foods such as ready-mixed casseroles, and dried steaks and other cuts for sportsmen. Meats comprise about 40 percent of all freeze-dried foods at present. They have the advantage of long life at room temperature, and considerable weight reduction. For current volume of production (2.3 million pounds, dried weight), with current technology (batch method of drying), processing costs exceed savings on transportation and handling. Improvement of continuous drying techniques within the next few years, and rising production volume, however, may reduce processing costs considerably. By 1975, one industry expert expects that the volume of freeze-dried meats may be as high as 177 million pounds. The greatest end-use may be as ingredients in processed convenience foods. Today, about 250 workers produce freeze-dried meats; by 1975, about 4,000 workers may be required.

A deterrent to faster growth of both irradiated meats and dried meats is the relatively advanced state of food handling in the United States, and the presence of refrigerator and freezer facilities in transportation, retail stores, and private homes.

Investment in new plant and equipment rose to a peak in 1964. The amount was $109.1 million in 1958, $145.7 million in 1964. Modernization has been stimulated by price pressure from retail chains as customers, and livestock growers and dealers as suppliers. The construction of new plants has been extensive, probably accounting for most of the capital expenditures since 1961.

Manpower Trends and Outlook

Productivity in meatpacking and processing may continue to rise rapidly over the next 5-year period. According to the U.S. Department of Agriculture, output per all employee man-hour for the meatpacking and sausage and prepared meats industry grew at an annual rate of about 4.5 percent between 1957 and 1963, after a more gradual rise of 1.8 percent annually during 1947–57. Because modernized slaughtering plants are accounting for an increasing proportion of total production, the rate of increase in output per man-hour may continue at its current high rate.

Employment decline is likely to continue, at a moderated pace, for the next few years. Productivity advance is expected to be greater than increases in output. Between 1957 and 1964, employment in meat products (including poultry) declined from 333,100 to 313,600 or 0.9 percent a year—after rising 1.9 percent annually from 1947 to 1957. The record of the 1958–64 period shows meatpacking plant employment declining, sausage and prepared meats employment remaining fairly steady, and employment in poultry plants (nearly one-quarter of all meat products employment) rising rapidly. The

	Average annual percent change
All employees	
1947–57	1.9
1957–64	– .9
Production workers	
1947–57	1.7
1957–64	–1.1
Output	
1947–57	1.7
1957–63	2.2
Output per all-employee man-hour	
1947–57	1.8
1957–63	4.5

proportion of production workers (4 out of 5 workers) in the meat products industry has not changed substantially since 1947.

Jobs occupied predominantly by women in meatpacking and processing have been reduced by introduction of automatic equipment. Partly because of mechanized and semiautomatic slicing, weighing, and packaging equipment for processsed meats and bacon, and automatic frankfurter and other sausage equipment, employment of women in the meatpacking and sausage and prepared meats industries declined by about 4,800 between 1958 and 1964, or about 1.8 percent annually. Women account for nearly one-third of all employees in sausage and prepared meats plants, and about a seventh of the employees in meatpacking (slaughtering) plants. In poultry plants, where women make up half the work force, production growth added about 5,800 women workers between 1958 and 1964.

Some Issues and Examples of Adjustment

Past closings of large meatpacking plants created complex problems of worker displacement. In 1960, the two principal unions and the Armour Company established an automation committee to study ways of mitigating layoffs among Armour workers. The committee reported in 1962 that when obsolete plants closed down, laid-off meatpacking workers—often middle-aged, and with less than high school education—had difficulty in finding new jobs because their skills were not usually transferable to jobs in other industries. Worker reluctance to accept lower wage rates for locally available operative and service jobs, or to relocate (due to community attachment and insecurity about moving), were also factors that hindered the placement of meatpackers in new jobs. Through programs sponsored by the Automation Fund (supported by a company-paid royalty on shipments), unions, and the government, retraining has been offered to workers in a number of locations where plants have been closed. The Automation Fund, however, is not typical in the industry.

Some contracts negotiated over the past 5 years include a variety of provisions for mitigating the impact of plant or department closings. New provisions include extensive transfer rights, early retirement provisions, technological adjustment pay, separation pay liberalization, and wage policies for the new jobs. Technological adjustment pay, negotiated in 1961 after some experience under the Armour Automation Fund, provides for guaranteed weekly minimum incomes to workers who have requested transfers to a new plant (from a closed plant or department), pending completion of transfer arrangements. Plant closings are preceded by a 3-month notice to employees, who then may choose to exercise transfer rights, early retirement (employees age 55 or over with 20 years of service), or accept separation pay.

Intensive bargaining has taken place over wage rates for new jobs. The combination of two jobs, or the substitution of a lower skilled machine task for a higher skilled manual one, creates new positions for which rates must be set. In 1964, a new provision in master contracts maintains wage rates in some cases where new equipment has changed the job but not the end product. Grievance activity has centered around rates for these changed jobs, and on the faster pace of the machine-controlled production lines. Changes in speed of slaughtering and dressing lines have led to some difficulties in labor-management negotiations.

Selected References

Technological Change

Bird, Kermit. *The Awakening Freeze-Drying Industry,* U.S. Department of Agriculture, Economic Research Service, January 1965, 13 pp.

"De Graff of AMI Tells Them Some Retail Operations May Go Back to Packers to Cut Distribution Costs," *The National Provisioner,* June 1, 1963, pp. 20–22.

"Methods and Equipment for Eviscerating Chickens," *Marketing Research Report,* No. 549, U.S. Department of Agriculture, October 1962, 55 pp.

"More Meat, Better Meat, Lower Cost," *Meat,* May 1963, pp. 24–28.

"Rail Systems Cut Costs," *Meat,* September 1964, pp. 26–29.

Thompson, John W. "Marketing Pickled Hides," Speech before the Tanner's Council of America, Edgewater Beach Hotel, Chicago, Ill., Oct. 20, 1965.

Urbain, W. M., O. S. Clemens, and H. P. Bonheimer. "A Continuous Frankfurter Process," *Food Technology,* May 1963, pp. 26–31 and 34.

Webb, T. F. and D. R. Hammons. "Fast Processing for Smoked Hams," *Agricultural Marketing,* U.S. Department of Agriculture, April 1965.

"What About the Next Thirty Years?" *Meat,* July 1964, pp. 48–51, 84, 86.

Williams, Willard F. and Thomas T. Stout. *Economics of the Livestock-Meat Industry,* New York, The MacMillan Company, 1964, 802 pp.

Manpower Trends and Adjustments

Conant, Eaton H. "Report and Appraisal: The Armour Fund's Sioux City Project," *Monthly Labor Review,* November 1965, pp. 1297–1301.

Industry Wage Survey: Meat Products (BLS Bulletin 1415, June 1964).

Officer's Report and Proceedings, Fourteenth Constitutional Convention, United Packinghouse, Food and Allied Workers, AFL–CIO, May 25–29, 1964.

"The Fort Worth Project of the Armour Automation Committee," *Monthly Labor Review,* January 1964, pp. 53–57.

Wilcock, Richard C. and Walter H. Franke. *Unwanted Workers* (New York), The Free Press of Glencoe, 1963, 340 pp.

The Dairy Products Industry (SIC 202)

Summary of Outlook Through 1970

Output will rise moderately during the next 5 years. An increasing proportion of fluid milk and ice cream will be processed through centralized control systems, and semiautomatic, clean-in-place equipment will be installed widely by 1970. Production will continue to shift to larger, more efficient plants. Employment is expected to continue to decline. The greatest reductions will take place among unskilled and semiskilled materials-handling jobs, and unskilled cleaning jobs.

Outlook for Technology and Markets

1970 output probably will be moderately higher than in 1964. While per capita consumption of fluid milk (on a milk equivalent basis) may decline slightly, U.S. Department of Agriculture experts anticipate that population growth will cause total milk production to rise at a rate of slightly less than 1 percent a year. More pronounced drops in combined per capita consumption of condensed and evaporated milk are expected to result in production declines for these products of about 1 to 2 percent a year. Production of butter, non-fat dry milk, and dry whole milk will remain substantially the same. On the other hand, production of cheese and frozen desserts may rise between 1 and 2 percent a year. New products are not expected to stimulate any significant growth in demand up to 1970, although sales of liquid low-fat milk are expected to increase.

Semiautomatic, clean-in-place (CIP) equipment is being installed in large volume operations. CIP systems automatically circulate cleaning solutions through pipes and valves (connecting pasteurizers, deodorizers, homogenizers, and heating and cooling equipment). CIP results in a lowered bacteria count in the final product, and less damage to equipment caused by daily dismantling of valves and fittings. Dismantling and cleaning work (involving chiefly unskilled entry jobs), which accounts for between 20 and 40 percent of all man-hours in a manually-cleaned plant, is reduced. About half of all milk is processed in plants using CIP; nearly all plants now being constructed are engineered with CIP built in, according to U.S. Department of Agriculture experts. By 1975, all fluid milk and a large proportion of ice cream will be produced through CIP equipment.

CIP, however, does not displace all hand cleaning, which is still necessary for some fittings, such as separator bowls and blades. Automatic spray units are rapidly being installed in holding tanks and mixing vats and bulk tank delivery trucks. Automatic air-operated valves can be cleaned in place by automatically pulsing them while the cleaning solution circulates; hand-operated valves must be dismantled and cleaned in tubs. Developmental work is being done with ultrasonic cleaning techniques that use sound waves to agitate cleaning solutions, producing a scrubbing action in the crevices and inside tubing of assemblies (such as centrifugal equipment).

An increasing proportion of fluid milk will be processed through central control systems. About 40 to 45 percent of all fluid milk is now produced through centrally controlled systems. Within the next decade, industry experts estimate that about 85 percent of fluid milk will be processed in central control plants, because large new plants are being constructed with centralized systems.

With a central system, a single operator can control the flow of raw milk through the various tanks, pipes, and processing equipment, using remote switches located on a central panel; and he can monitor the processing by means of instruments that measure and record temperature, weight, pressure, and other processing variables. Under older systems, a small crew of skilled workers was required to move among tanks and lines, manually adjusting connections, opening and closing valves, and initiating each process step.

An industry expert estimates that of all plants now using central control, 60 percent have remote control of raw milk receiving, processing, and filling operations; 30 percent centrally control the receiving and processing steps only; and 10 percent have central control for only one step, such as processing only, or receiving only.

Centralized control incorporates CIP. Total labor savings per unit of output, over manual control and conventional cleaning, amount to over 50 percent in processing operations. In cleaning only, laborsavings are 60 percent or greater, and problems in scheduling cleaning labor are greatly simplified.

There is a trend toward continuous processing of manufactured milk products, such as cheese and ice cream. Methods which reduce acidifying time from hours to minutes, by direct addition of food acid instead of by culturing, are in developmental stages now. Mechanization of cheddaring and other cheesemaking processes will advance rapidly over the next 5 years, so that by the early 1970's, continuous hard and cottage cheesemaking is likely to be in operation in large cheese plants. A U.S. Department of Agriculture expert expects that output per man-hour in cheesemaking stages prior to aging and packing will be doubled or even tripled by these processes.

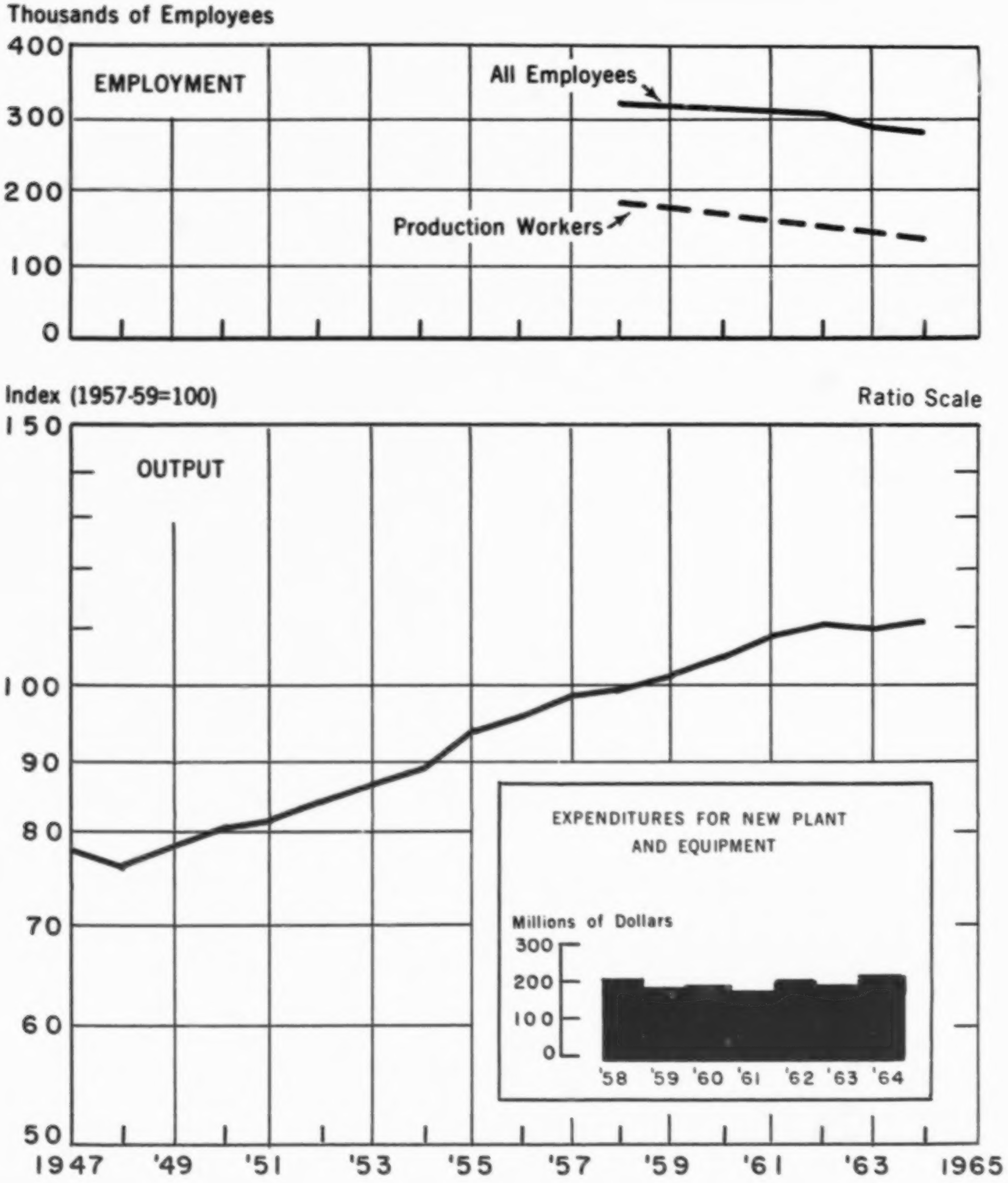
Large ice cream plants are installing centralized control systems for some of their operations. Within the next decade, an equipment supplier estimates that about 65 percent of all ice cream will be processed with some centralized controls. Of the few plants now using this system, about 20 percent have four-fifths of their processing work under central control, and 10 percent have about half of their processing so controlled. Recently introduced methods for fast plate contact hardening make it possible to move ice cream continuously—from processing through packaging, hardening, palletization, and directly out to the delivery truck —by reducing hardening time from about 15 hours to approximately one hour. This faster processing makes production more responsive to orders, thereby reducing labor-intensive inventory handling in the cold room.

Fluid milk plants are using materials-handling equipment and improving plant layout to reduce rehandling labor. Some types of equipment that are reducing heavy hand labor are: automatic bottle and carton casers; case conveyors; and equipment which automatically stacks cases onto pallets for forklift truck or conveyor handling, or unstacks them for cleaning and refilling. Multiple handlings are eliminated by conveyor patterns which permit continuous flow of product from filling lines through cold storage, and simplified shipping and receiving dock layouts which permit maximum use of palletization and extension of the conveyors onto trucks. Second and third case handlings can be reduced 50 percent or more with an advanced type of conveyor that balances uneven volumes of case receipts with steady pace of case delivery to the filling lines.

Manufacturing plants now are converting to bulk tank reception. Insulated bulk tank trucks pick up milk from refrigerated bulk farm tanks, delivering their loads directly through hoses to the milk plant holding tanks. According to a U.S. Department of Agriculture study, labor requirements per unit are reduced about 75 percent in the receiving operation in a plant receiving between 5,000 and 14,000 gallons daily; somewhat less in a slightly larger plant. Handling and washing of cans are eliminated, and milk quality is maintained through constant refrigeration and elimination of open pouring. Bulk milk transport also has the effect of broadening market areas. It permits interplant shipments that can divert excesses of raw milk from fluid milk bottling to more distant manufacturing plants. Plants producing most of the fluid milk already are converted to bulk tank reception; this conversion will probably be completed in remaining plants within the next 5 years. Manufactured product plants are now converting at a rapid rate.

Milk supply is becoming somewhat less seasonal, thus mitigating extreme seasonality in manufacturing such products as dry milk and cheese. Technological factors reducing milk supply seasonality include improved cow feeding practices and breeding cycles. Interplant shipment systems and wider market areas for raw milk reduce seasonality for some plants, widen it for others. Between 1950 and 1964, the

EMPLOYMENT, OUTPUT, AND CAPITAL EXPENDITURES IN DAIRY PRODUCTS



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board; expenditures, Bureau of the Census.

disparity between November (trough) raw milk production and May (peak) production was reduced from 54 percent to 31 percent. However, further reductions are expected to be smaller. Reduction of seasonality promotes more efficient plant operation and reduces layoffs and seasonal hiring patterns. In some rural areas, seasonal labor may be increasingly scarce. In one university survey, plant managers reported that they considered it would be more efficient to maintain an experienced work force than to rely solely on temporary seasonal hiring to run milk manufacturing operations. Fluid milk plants also are reducing operations to a 5- or 6-day week, rather than a 7-day week.

Fluid milk distribution patterns are changing. Over the past decade, an increasing proportion of milk has been sold through retail stores, chiefly supermarkets. Home delivery (now about 30 percent of all fluid milk sold) is expected to continue declining as a proportion of all milk sold. Store purchasing of milk (either at supermarkets or convenience or dairy stores) has been encouraged by relatively higher prices for home-delivered milk; increased shelf-life of milk due to improved farm methods, improved sanitation and refrigeration at all stages of processing and storage; development of larger containers; and an increase in one-stop supermarket shopping.

New preserving methods for fluid milk may further alter distribution patterns. A new process which sterilizes milk, reducing or eliminating the need for refrigeration and increasing shelf-life to 6 months, could have a major effect on the milk distribution system and the location of fluid milk plants—if sterile milk is perfected and accepted as a substitute for pasteurized milk. Sterilized concentrated milk is also in developmental stages. Fluid milk processing would increase in low-cost milk producing States, and the product could be shipped to such areas as the Far West and Southwest, where milk production costs are relatively high. Since refrigeration would not be necessary, frequent store or home delivery of milk would no longer be required, and trucking and consumption patterns might take on the characteristics of the canned food market.

Frozen concentrated milk is also in an early developmental stage. If consumers accept this product as a substitute for fresh milk, similar changes in location of processing plants and trucking would take place, although freezer facilities would be necessary in trucks, stores, and homes. Both types of product face problems of taste and consumption habit.

The number of dairy products plants is declining, while plant size is growing. The number of dairy plants declined from 9,879 to 7,890, a drop of 20 percent between 1958 and 1963, while total output rose. The number of large fluid milk plants (producing over 10 million quarts a year) has increased 57 percent between 1950–51 and 1961–62; the number of small plants (producing under 1 million quarts) fell by 44 percent, according to the Federal Trade Commission. Average plant size is expected to continue increasing over the next decade, partly because improved refrigeration, better roads, and faster transportation methods insure product quality even when marketing areas cover several States. The present rate of plant closings is expected to decline by the early 1970's. The West Coast and South, however, are expected to experience particularly extensive plant consolidation in the near future.

Investment in new plant and equipment has fluctuated around $200 million a year in the past few years. Much of recent expenditure was for large plants which service areas once covered by a number of smaller plants. Consumer preferences, governmental price and purity regulation, and the perishable nature of the product exert a limiting influence on changes in dairy technology.

Manpower Trends and Outlook

Employment is expected to continue to decline. Productivity increases exceeding the moderate gains in output may continue to reduce employment of production workers; declines among drivers may continue due to further changes in delivery practices. Total employment fell from 319,100 to 288,600 between 1958 and 1964, at an average annual rate of 1.7 percent. Production workers declined more rapidly

	Average annual percent change
All employees	
1958–64	−1.7
Production workers	
1958–64	−4.9
Output	
1947–57	2.4
1957–64	1.6

from 182,800 in 1958 to 134,700 in 1964, or at an average annual rate of 4.9 percent. In the fluid milk industry (which accounts for over 70 percent of all dairy employment), the corresponding rate of decline for production workers between 1958 and 1964 was 6.2 percent. Nonproduction workers in fluid milk plants (in 1964, about 60 percent of all fluid milk employees) grew at an annual rate of 3.0 percent during the same period. About two-thirds of this group is comprised of driver-salesmen, or routemen, who deliver milk to stores and homes. One-third are office, managerial, or technical and professional employees.

Process workers will decline gradually, while more rapid reductions will take place in materials handling and cleaning jobs. The trend toward larger plants, larger volume process equipment, and centralized controls will permit some reductions among processing employees in milk and manufactured milk products plants. Unskilled labor requirements in materials handling in cold rooms, warehousing, and bottle cleaning will continue to fall rapidly. For example, the U.S. Department of Agriculture reports that in a model, medium-size plant, 4 of the 6 men engaged in packaging and case handling could be eliminated by automatic casers, stackers, unstackers, and case dividers. Two of the four men engaged in receiving and processing milk are eliminated by the central control system. Special cleaning crews will be reduced substantially to one part-time employee in plants installing CIP and central control equipment.

Routemen may continue to decline. The impact on the industry of larger truck sizes, reduction in number of stops due to supermarket volume deliveries and less frequent home deliveries, and materials-handling equipment which extends into trucks, may continue through the next decade. If sterile or frozen concentrated milk is generally accepted as a substitute for fresh milk by the late 1970's, drivers on home delivery routes may be severely affected; wholesale (store delivery) drivers will also experience some reductions.

Office and other nonproduction jobs will not increase substantially, although skill requirements may rise. Office workers may decline substantially, due to increased use of small computers for route accounting and inventory records. Technical personnel (chiefly laboratory staff) and highly skilled maintenance workers (specializing in instrumentation and control system repair, heating and cooling equipment, metalwork, and plumbing) will be needed in small numbers in the large-scale plants which account for an increasing proportion of milk products. In smaller plants, maintenance and repair are frequently done by a production worker or an all-round maintenance man.

Some Issues and Examples of Adjustment

Early retirement provisions have been introduced in recent contracts. Pension programs, often administered jointly by the union and companies in a metropolitan area or region, are being liberalized to permit early retirement—as early as age 52 after 35 years of service, in some cases—on reduced pensions. Compulsory retirement at age 65 has been introduced in some contracts.

Four-week vacations after 20 years of service have become common in some metropolitan areas; scheduling is used to avoid layoffs during the slack season. Some recently negotiated contracts provide 3 weeks after 10 years (or less) of service, 4 weeks after 15 years. The third and fourth week of vacation, in some areas, may be scheduled by management and used to reduce the work force on duty during slow seasons.

A variety of approaches to adjustment has been used in some major cities. In St. Louis, for example, when the workweek for routemen was reduced from 6 to 5 days, drivers were guaranteed their jobs for 1 year after the reduction. The companies set up a bureau responsible for assisting in the placement of surplus routemen in jobs in other industries. At the end of the year, all surplus routemen had obtained employment elsewhere.

In Pittsburgh, a supplemental contract on automation (covering both plant and route employees) provides that the union will be given advance notice of technological change, and that a company introducing laborsaving equipment will retain five employees who would otherwise have been laid off. Additional employees who are laid off are to be placed on an "Automation Unemployment List," from which all Pittsburgh companies covered by the areawide contract must hire (after their own laid-off employees have been rehired). A maximum of 9 months of supplemental unemployment benefits are provided for workers on the list. In Chicago, where a similar automation clause has been negotiated, SUB payments are to be increased according to the number of dependents supported by the laid-off employee.

Selected References

Technological Change

Fitzpatrick, John M., and Charles E. French. "Impact of Seasonality of Milk Supplies on Labor Costs and Efficiency in Dairy Manufacturing Plants," Research Bulletin 774, Purdue University Agricultural Experiment Station, March 1964.

Graf, Truman F. "Trends and Impact of Sterilized Dairy Products," *The Milk Dealer*, July 1964, pp. 44–46.

"Layouts and Operating Criteria for Automation of Dairy Plants Processing Milk and Half-and-Half," Marketing Research Report 568. U.S. Department of Agriculture, March 1963.

"Layouts and Operating Criteria for Automation of Dairy Plants Processing Milk, Half-and-Half, Cream, Chocolate Drink, and Buttermilk," Marketing Research Report 591. U.S. Department of Agriculture, September 1963.

O'Connell, Paul, and W. E. Snyder. "Cost Analysis of Fluid Milk Processing and Distribution in Colorado," Technical Bulletin 86. Colorado State University Experiment Station (no date).

Proceedings—Food in the Future: Concepts for Planning, Dairy and Food Industries Supply Association, Washington, 1964.

Proceedings of the Thirteenth Annual Dairy Engineering Conference, Michigan State University, 1965.

Saal, Herbert. "Materials Handling, Some Guidelines and Principles," *American Milk Review*, July 1964, pp. 30–31, 48.

Manpower Trends and Adjustments

Industry Wage Survey, Fluid Milk Industry, September–October 1964 (BLS Bulletin 1464, 1965).

Potter, Paul. "What to Expect From Labor in '65," *American Milk Review*, January 1965, pp. 48–50.

The Flour and Other Grain Mill Products Industry (SIC 2041)

Summary of Outlook Through 1970

Output is expected to continue to rise slowly and the growth in output per man-hour is expected to continue. Major mills are planning modernization projects. The most significant technological advances are pneumatic materials handling, impact milling, and air classification. Other innovations include quality control techniques and equipment. It is anticipated that employment will continue to decline.

Outlook for Technology and Markets

Output is expected to rise slowly. Output increased at an annual average rate of 1.6 percent between 1957 and 1963 and is expected to increase at about the same rate through 1970. From 1947 to 1957, output declined at an annual rate of 2.1 percent. A leveling-off in the rate of decline in per capita consumption during 1957–63, and the growth in population, reversed this trend.

New products are being developed in efforts to increase consumption. Declining per capita consumption, as well as a decline in the industrial utilization of wheat products, is stimulating the development of improved and new products. Agglomerated flour, introduced in 1964, is formed by sprinkling regular, finely ground flour and passing the resulting larger particles over a sieve to obtain particles of a uniform size. Flour made up of such particles is more absorbent and thus mixes more readily than conventional flours. Although some use of agglomerated flour by household consumers has been reported, it has not yet been accepted by the baking industry and its commercial impact thus far has been negligible. Another new product, a concentrated mixture of wheat starch and insoluble protein, is used as a base for infant and geriatric foods.

Some new products for industrial use are being developed by the industry in a cooperative program with the U.S. Department of Agriculture. For example, a water-resistant glue, made up of protein and a new starch product called dialdehyde starch, is suitable for bonding interior grade plywood. Recently developed wheat starch products are used for internal paper sizing, for external application to add both wet and dry strengths to the paper, and as a warp sizing in the textile industry. Efforts to fabricate insulating board and formed board products from wheat and its byproducts are in the experimental stage.

Pneumatic materials handling could greatly improve efficiency of the milling process and facilitate loading of flour. Pneumatic materials handling in milling eliminates bucket elevators and screw conveyors and the accompanying dead pockets of flour particles that can be a source of infestation. It also reduces the amount of flour dust in the atmosphere and the accompanying fire hazard. Other advantages are improved sanitation and reduced space requirements. In addition, pneumatic conveying facilitates continuous operation and the use of on-stream (in process) analysis techniques.

Impact milling can improve milling efficiency. Impact milling machines can be used to replace the present standard equipment at some stages of the milling process, but it appears unlikely that the conventional roller mill process will be significantly displaced in the next decade.

In conventional roller milling, five sets of corrugated break rolls are used in the break section of the mill to fracture the wheat and to free the endosperm portion; the endosperm portion is then reduced to flour in from six to nine sets of smooth rolls in the reduction section of the mill. When impact mills are used, the last two sets of corrugated rolls in the break section, and up to three or four sets of smooth rolls in the reduction section may be replaced with impact mills. Here the particles of endosperm or flour are hurled by centrifugal force against pegs of stationary and moving impactors within the impact milling machine.

Use of impact milling in the reduction section reduces starch damage and elongation of particles (a deficiency at the final stages of conventional milling). Impact milling has been helpful in particle size reduction for air classification of flour. Also, repair of an impact milling machine does not require shutdown of the entire milling process. Other advantages are that impact mills are easier to regulate, can produce finer flour than an all-roller operation, are easier to clean, and may produce greater yields than conventional roller mills.

Air classification makes possible a more efficient utilization of many wheats. Air classification separates the finished product, flour, into fractions of higher and lower protein content. In one type of air classifier, the flour is fluidized in air and passes to the outer periphery of a high-speed revolving disc. Here the smaller and lighter particles (the high-protein fraction) are carried through the rotor by an air stream, while the larger and heavier particles (the low-protein fraction) are thrown out to the wall of the classifier by centrifugal force.

This process makes possible the production, from any wheat, of a flour having a desired protein content. (Protein contents of wheat differ by variety and class of wheat, as well as from area to area, depending on soil and climate.) The need to shut down a mill to adjust to different area wheats can be eliminated. Many wheats can produce either a low protein flour for cake bakeries or a high protein flour for bread bakeries. An industry source estimates that air classification is used on only about three percent of total flour output.

Studies by the University of Nebraska indicate that new air classification equipment can be paid for out of savings in transportation and storage in a 6- to 24-month period, depending on location of the plant. According to a 1965 survey by *Northwestern Miller,* about 9 percent of survey respondents intended to purchase air classification equipment.

Many new instruments make possible more scientific control and time savings in the milling process. An electric seed counter using a photoelectric cell and a vibrator, for example, can help forecast flour yield in about 3 minutes compared to 10 minutes required in the manual method, and is more accurate. Another new instrument using the principle of a medical blood cell counter electronically determines particle size in a few minutes, is claimed to be a more accurate measure than air stream analysis and faster than the older weighing practices. One new piece of equipment determines the protein content in grain and flour, reducing analytical time from hours to minutes. Another set of instruments weighs a moving stream, improving the control of conditioning and processing. The new instruments for determining kernel weight, flour particle size, and protein content make possible a rapid analysis of some of the important factors in the milling process.

Instrumentation and laboratory analysis are helping the craft skill of the head miller who has been largely dependent on "see and feel" methods of determining the quality of the flour through all stages of processing.

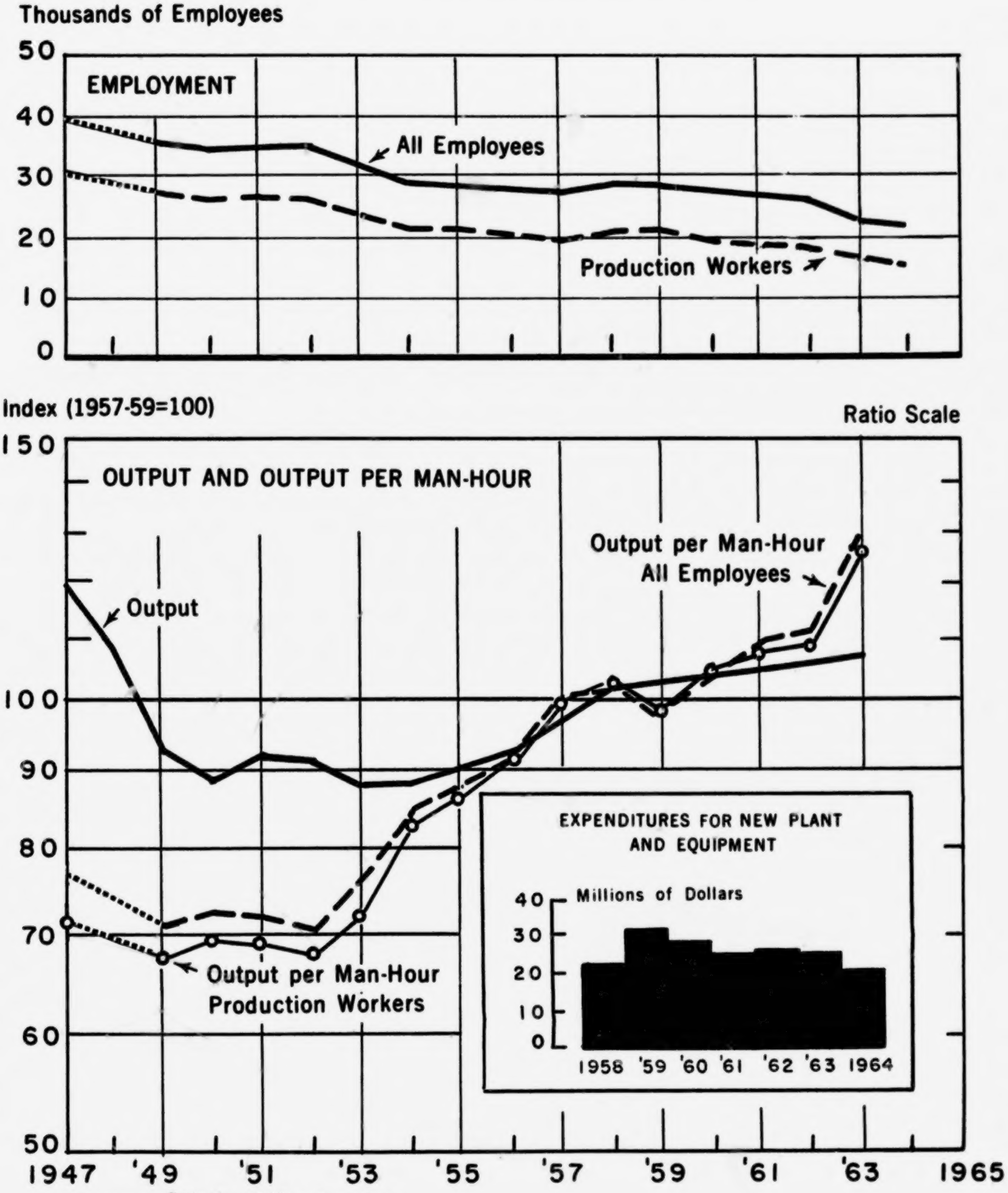
Irradiation to eliminate pests may afford some advantages. Preliminary experiments by the U.S. Department of Agriculture and the industry are in process to determine the net advantage, if any, of using irradiation for disinfestation. Negative aspects, which must be overcome before commercial use, are possible adverse effects on the food value of the grain itself and on the baking qualities of the irradiated flour.

Significant expenditure on new equipment is indicated. Capital expenditures for 1964 totaled $21.7 million compared to $31.1 million in 1959, a year when mills spent heavily on air classification systems. Plant and equipment spending probably will increase over the next few years as plants are modernized. The *Northwestern Miller* survey indicated that 128 mills representing about 60 percent of U.S. flour milling capacity, intended to engage in modernization projects. Of the 128 mills, 81 declared their intention of investing in pneumatic conveying equipment, 64 in general dust control equipment, 63 in new sifters, and 54 in purifiers. Other major expenditures (at least 40 mills participating) will be made on seed and impurity removal, packing, bulk loading, and bulk storage.

Manpower Trends and Adjustments

Outlook is for continued growth in productivity. Output per man-hour increased at the annual average rate of 4.3 percent for all employees and 3.9 percent for production workers, from 1957 to 1963. The average annual rates of in-

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN THE FLOUR AND OTHER GRAIN MILL PRODUCTS INDUSTRY



Sources: Employment and expenditures, Bureau of the Census; output and output per man-hour, Bureau of Labor Statistics.

Average annual percent change	
All employees	
1947–57	–3.8
1957–64	–3.0
Production workers	
1947–57	–4.3
1957–64	–3.1
Output	
1947–57	–2.1
1957–63	1.6
Output per all-employee man-hour	
1947–57	2.7
1957–63	4.3
Output per production worker man-hour	
1947–57	3.4
1957–63	3.9

crease for the 1947–57 period were 2.7 percent for all employees and 3.4 percent for production workers.

Prospects are for decreasing employment. From 1947 to 1957, employment (Census data) in flour and other grain mill products declined from 39,597 to 27,085, an annual rate of decline of 3.8 percent. Over the same period, production workers declined from 30,821 to 19,931, an annual rate of decline of 4.3 percent. Between 1957 and 1964, the annual rate of decline slowed to about 3 percent for both groups of workers, from 27,085 to 21,930 for all employees and from 19,931 to 15,985 for production workers. It is probable that employment will continue to decline, but at slower rates.

Workers may be displaced as less efficient plants are closed. A total of 814 plants, most of these with fewer than 20 employees, were operating in 1958 compared to 1,243 in 1947. The contraction has continued. One large producer, for example, announced in June 1965, the closing of 9 of its 17 plants, displacing 1,400 employees. Because of competitive pressures, increases in transportation costs, and other factors, the trend is to concentrate output in more efficient mills and in mills closer to consumer markets, in an effort to reduce overall costs of production.

Severance pay is provided to some displaced workers under collective bargaining agreements. Two-fifths of the production workers and nearly one-sixth of the office workers in 1961 were employed in mills having provisions for severance pay in the event of displacement because of technological change or mill closings.

Selected References

Cantor, S. M. and W. H. Harte. "Recent Developments in Wheat Processing Technology," *Chemurgic Digest,* April–May 1963, pp. 3–4, 7.

Drake, Austin T. "Developments in Milling Modernization," *Food Technology,* April 1962, pp. 24–27.

Graham, John C. "The Use of Air Classifiers in the Flour Milling Industry," *The Northwestern Miller,* May 1965, pp. 25–32.

Henoch, Ruth L. "What Scientists and Mill Management Say of Grain and Flour Irradiation Possibilities in 1964," *American Miller and Processor,* May 1964, pp. 9–11.

Industry Wage Survey, Flour and Other Grain Mill Products, November 1961 (BLS Bulletin 1337, 1962).

Johnson, Robert M. and Tyler F. Hartsing. "Kernel Count as a Measure of Flour Milling Yield," *The Northwestern Miller,* Nov. 11, 1963, pp. 22–26.

Mast Jr., C. L. "Your Future in Research," *The Northwestern Miller* Jan. 20, 1964, pp. 38–45.

Sloggett, Gordon R., Paul J. Mattern and Richard G. Walsh "Air Classification of Wheat Flour, A Case Study of the Economic Effects of Technological Progress," Part I, *The Northwestern Miller,* Feb. 17, 1964, pp. 12–18; and Part II, Mar. 7, 1964, pp. 11–18.

Speight, John. "Fractionation of Flour," *The Northwestern Miller,* Nov. 11, 1963, pp. 39–50.

Trotter, W. K. and D. L. Miller. "Economics of Air Classifying Typical Wheat Flours," *American Miller and Processor,* June 1964, pp. 8–11.

The Bakery Products Industry (SIC 2051 and 2052)

Summary of Outlook Through 1970

Modernization of bakery products plants involves the application of continuous processing techniques to mixing, baking, wrapping, and freezing of products; the use of computers in warehousing and inventory control; and improvements in materials handling. As newer and more efficient production facilities are installed, output per man-hour may rise at a faster rate than during 1957–63. Output probably will increase at the low rate of past years. Employment decline is expected to continue because of the slow growth in output and increasing pace of modernization.

Outlook for Technology and Markets

Output is expected to increase at the 1957–63 rate. Output increased at an annual rate of 1.4 percent between 1947 and 1957, and 1.5 percent annually from 1957 to 1963, according to the U.S. Department of Agriculture. Increasing demand for bakery products because of population growth is expected to more than offset declining per capita consumption of baked goods and increased competition from prepared mixes.

Improvements in materials handling reduce production time and manpower requirements substantially. Pneumatic conveyors which unload flour from railroad cars at the rate of 10 tons per hour are being used increasingly. Other dry materials such as soda, salt, dry milk, and sugar are unloaded in the same fashion. A large bakery using pneumatic conveying can increase productivity in bulk materials handling operations as much as 40 times. Use of pneumatic conveying, however, is limited to large bakeries.

New ways of handling sugars and reconstituted milk in the liquid state, liquid yeast, and fats and oils (a fluid shortening which is mixture of hard fat with a liquid oil), by pumping them into storage tanks directly from trucks and railroad cars, result in considerable saving of time and labor over manual bulk handling. Handling of wrapping materials in pallet loads also has decreased materials handling man-hour requirements.

Some of the larger wholesale bakeries are using centralized control panels for metering. Some metering systems are adjusted automatically to plant variations in temperature and humidity.

Some plants are using computers to regulate the flow of raw materials. All materials are stored in tanks to aid the direct metering mixing machines. In one major bakery, a digital computer is used to select, meter, and control the weight of five to nine dry and liquid raw materials (the number of materials depending on the product) in the flow from the storage bins to the scale hoppers, with a 0.1 percent accuracy. In order to begin the raw dough mixing, 16 individual steps are carried out by the computer, which automatically controls valves, motors, blowers, and electro-pneumatic and mechanical devices.

Continuous mixing is helping to speed up breadmaking in large bakeries. Breadmaking is becoming more automated, the continuous mixing method being an important step toward complete automation of the baking process. Continuous mixing is automated only partially as it can be continuous only after pre-fermented brews are made in batches. Elimination or reduction of brew fermentation time to a very short period is necessary to complete automation. Brew time has been reduced from 6 hours required at the time of its introduction in 1954 to 2 to 2.5 hours today, compared with the 4 to 6 hour standard sponge and dough procedure. Proofing and baking times are essentially the same. Sifted flour, the batch mixture of prefermented brew and oxidizing solution, and liquid or melted shortening are fed continuously at predetermined rates into a premixer.

The resulting dough is metered into a developer in which it is stretched and folded over and over by two counter rotating impellers, then extruded, divided, and panned to the accuracy of one gram per pound. Overall processing time, from mixing to oven, is lowered substantially and provides a potential for a significant increase in productivity.

Other advantages claimed for continuous mixing include improved sanitation due to simple and effective cleaning, greater uniformity in the final product, and floor space savings as high as 60 percent over conventional equipment. The new technique was originally limited to white, rye, and whole wheat bread. Further research and development is being devoted to the use of continuous mixing for rolls and other specialty products. Over 30 percent of all bread is made by continuous mixing. However, the high cost of the equipment makes this process uneconomical for bakers whose output is less than 100,000 pounds per week.

The combining of various dough preparation stages into one machine that will mix, develop, divide, and pan bread dough in one continuous operation has linked automatic ingredient handling with dough preparation, the automatically controlled oven, and the depanner, slicer, and wrapper.

Conveyorization is being improved. New and faster conveyorization techniques provide a continuous movement of the panned dough through proofing and through the oven to depanning, cooling, slicing, wrapping, and labeling. New travel ovens may be 100 to 300 feet in length, gas fired, and fitted with continuous stainless steel mesh bands for conveying the product through the oven. Temperatures can be thermostatically controlled through seven heat zones to provide the required heat for specific products. The continuity of conveyorization has been enhanced further by the development of new automated depanners that reduce drastically the time for this operation. New glazed pans require little or no greasing, and consequently, less cleaning which may result in some reduction in manpower requirements in this department.

Freezing of bakery products may change marketing and distribution structure. Most freezing of bakery products is done in a freezing room or tunnel cooled to about −40°F., by a mechanical refrigeration system. A new method, in experimental use only, uses a liquid nitrogen mist to fast freeze the products at −320°F., the lack of air preventing oxidation. Advantages of the new method are said to be improved taste and preservation of the fresh quality, but it has thus far been found too expensive to apply on a commercial basis.

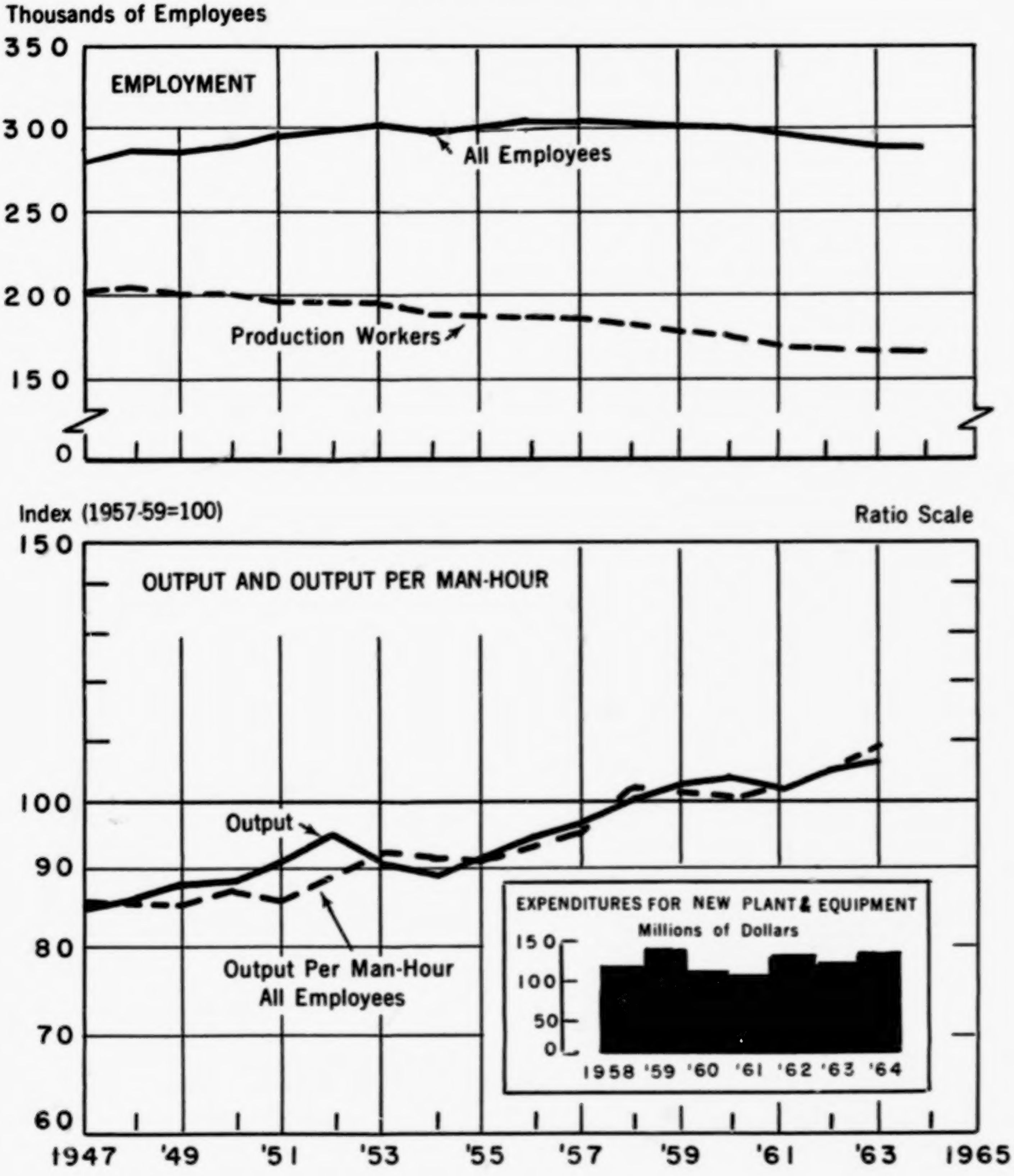
In 1961, 40 percent of 1,300 bakeries were freezing part of their production, according to a survey by the U.S. Department of Agriculture. Although freezing of bakery products (freezing is applied to about 400 products) is more prevalent among retail bakeries, a growing proportion of wholesale output is being frozen. Freezing enables the small retailer, as well as the large wholesalers and supermarkets, to maintain larger and more varied inventories, including a frozen dough inventory which can be subsequently defrosted and baked off as needed for sale.

One of the results of baking for frozen inventory may be to reduce or eliminate the uneven utilization of labor and equipment characteristic of the industry, particularly in wholesale bakeries. Some bakeries are shut down Saturday, start baking again on Sunday, fresh products being delivered early Monday. One study of 20 wholesale bakery plants showed that Friday's production was at 100-percent capacity, but Tuesday's average production was down to 57 percent, the average not including five plants which were closed. Frozen distribution also allows for less frequent delivery to retail outlets, reduces significantly losses due to nonsaleable stale products, makes possible a larger and more varied supply at distribution centers, and, by widening geographical marketing areas, increases competition among wholesalers and between wholesale and retail bakeries.

Measures to control deterioration and increase shelf life are being studied. One of the most promising methods for increasing shelf life is the use of microwave energy to inhibit bread mold. In one experiment, microwave-treated bread was free of mold after 10 days, while conventionally treated bread was moldy.

Research on the use of irradiation—i.e., gamma rays given off by radioactive substances—to prevent spoilage has not been as extensive on bakery products as on bacon, potatoes, wheat, and some other products. The limited

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN THE BAKERY PRODUCTS INDUSTRY



Sources: Employment, Bureau of Labor Statistics; output and output per man-hour, Department of Agriculture.

research on bakery products, however, has not yet proven irradiation successful as a means of preservation. Success in this research might have a significant impact on bakery marketing practices and employment.

Electronic data processing (EDP) is being applied to warehousing and inventory control. Computer controlled cranes, capable of placing pallet loads of the finished baked production in 1 of 650,000 locations within a warehouse, are used by one midwest wholesale baker. Executing 180,000 warehouse instructions every 3 seconds, the computer memorizes (and affirms) where pallet loads have been placed. Each customer's order is filled on a predetermined fifo (first in, first out) basis.

Some companies are using computers for crediting daily production and sales data, to reduce distribution costs. One bakery used a computer to determine the profitability of their product mix, and was able to reduce a line of 108 items to 85 by dropping 29 and adding 6 new, more profitable items. Accurate and up-to-date records make possible more efficient truck loadings in terms of saleable products with fewer returns and less deterioration. Computerized bookkeeping is claimed to facilitate collections, thereby enabling the routemen to devote more time to sales.

Capital expenditures expected to be at a high level. Capital expenditures averaged about $123 million annually between 1958 and 1963, and in 1965 are expected to exceed that level. According to *Baking Industry* (Annual Survey number, June 5, 1965), 34 percent of wholesale bakeries would spend more than in 1964; 47 percent would continue spending at the 1964 rate, while only 17 percent of wholesalers covered in the survey planned to spend less on capital improvements in 1965 than in 1964. The survey showed that in 1965, 15 percent of supermarket bakery firms intended to purchase conveyors; 23 percent, mixers; 15 percent, ovens; and 31 percent, freezing and refrigeration equipment.

The survey also indicated a high potential for future modernization. In five geographic areas, comprising the entire country, bakers were asked to evaluate the extent of "automation" in their plants, as they understood the term. Results of the survey for large plants showed that in two of the areas, only 55 percent of the plants were considered to be partially automated; in another area, 50 percent, and in two areas, about 43 percent each. A negligible proportion of large plants were reported fully automated. Small- and medium-size bakeries reported significantly smaller percentages partially automated than did large bakeries, in 4 of the 5 districts.

Manpower Trends and Adjustments

Output per man-hour will probably continue increasing through 1970. Output per all-employee man-hour increased at an average annual rate of 1.3 percent between 1947 and 1957; the rate between 1957 and 1963 was slightly higher —an average annual rate of 1.8 percent.

Employment is expected to decline slightly. Although employment probably will continue to decline, slowly increasing demand for bakery products from a growing population will tend to hold the decline to a moderate rate. Employment increased from 280,700 in 1947, to 302,500 in 1957, but between 1957 and 1964, declined to 289,900.

Production worker employment—166,500 in 1964—declined 1 percent annually from 1947 through 1957 and 1.4 percent annually between 1957 and 1964. As a percent of the work force, production workers declined from 72.5 percent in 1947 to 60.8 percent in 1957, and to 57.4 per-

	Average annual percent change
All employees	
1947–57	0.8
1957–64	– .6
Production workers	
1947–57	–1.0
1957–64	–1.4
Output	
1947–57	1.4
1957–63	1.5
Output per all-employee man-hour	
1947–57	1.3
1957–63	1.8

cent in 1964. The decline in the proportion of production workers reflects the sharp increase in the number of deliverymen and routemen over this period.

Need for technically trained personnel is expected to increase. The baking industry is establishing a National School in Baking Science and Management for the training of highly skilled personnel, engineers, and scientists, for which there is an increasing demand.

Measures for adjustment have been included in some contracts. Mechanization and automation clauses providing up to 600 hours of pay—depending upon length of service—for employees who are displaced as a result of technological change have been incorporated in some contracts.

Coverage by pension and welfare funds is portable in a large percent of the industry where contractual relationships exist with a union.

Selected References

Bayfield, E. G., and William E. Young. "Flour Brew Studies," *Baker's Digest*, June 1965, pp. 50–54.

Cotton, Robert H. "Food Standards Viewpoint of the Baking and Frozen Food Industry," *Food Technology*, November 1964, pp. 43–45.

Davis, Russell E. "Outlook 1965," *Baking Industry*, Jan. 2, 1965, pp. 21–28.

Faw, James E., Jr. "Automation in the Bakery Industry," *Automation*, July 1962, pp. 127–129.

The Freezing of Commercial Bakery Products: Current Practices, Problems and Prospects. U.S. Department of Agriculture, Economics Research Service, Marketing Economics Division.

Gomolak, Louis S. "Take Two Tons of Flour. . . . ," *Electronics*, Apr. 20, 1964, pp. 84–89.

Lipstreu, Otis and Kenneth A. Reed. *Transition to Automation: A Study of People, Production and Change*, Series in Business No. 1, University of Colorado Press, 1964, 156 pp.

Matz, Samuel A. *Baking Technology and Engineering* (Westport, Conn., Avi Publishing Company, 1960), 640 pp.

Miller, Ross. "Automation for Increased Production," *Baking Industry*, Feb. 1, 1964, pp. 29–31.

Snyder, James D. "Food Irradiation, What's in Store For Bakery Products and Ingredients," *Bakery Industry*, Oct. 10, 1964, pp. 29–31.

Walsh, Richard G., and Bert M. Evans. *Economics of Change in Market Structure, Conduct, and Performance in the Baking Industry 1947–1958*, University of Nebraska Studies, New series No. 28, December 1963.

The Malt Liquors Industry (SIC 2082)

Summary of Outlook Through 1970

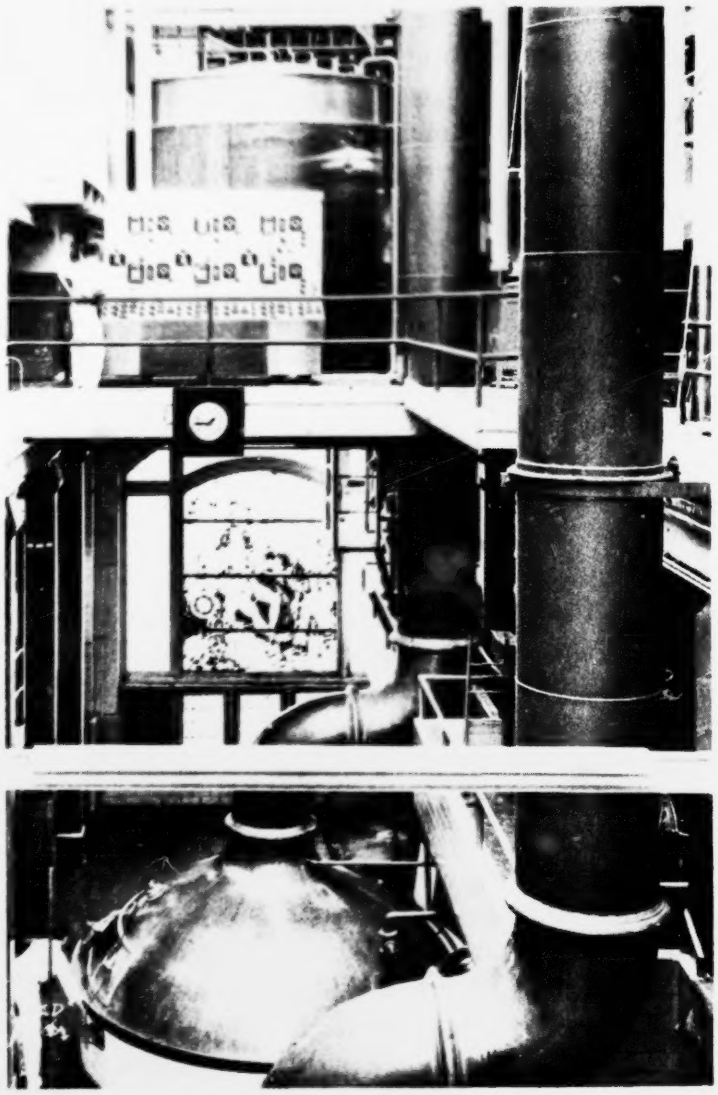
Beer production will probably increase at a faster rate than in the decade 1955–65. As new plants are built, old plants modernized and obsolete ones closed, output per man-hour will probably continue to rise at a fairly rapid rate. Control instrumentation and mechanization of cleaning and materials handling are among major factors reducing unit labor requirements. Future developments may include continuous processing and the use of concentration. Employment in the malt liquors industry probably will continue to decline, but at a slower rate than in the recent past. Labor-management agreements have been adopted that shorten worktime through provisions for early retirement and longer vacations.

Outlook for Technology and Markets

A rate of output growth exceeding recent rates is expected. Output (BLS composite index) increased at an annual rate of 0.8 percent between 1947 and 1957, and 2.2 percent annually from 1957 to 1963. Per capita consumption is rising; it amounted to 15.9 gallons in 1964, compared with a low (in 1961) of 15 gallons. Many industry experts believe that the rise in per capita consumption will continue, due to a relatively greater increase in the population in the 20–40 age group during the decade 1965–75. The introduction of new varieties of malt beverages, new container sizes (such as home kegs), and emphasis on convenience packaging (such as zip top cans) and response to advertising directed to previously nonbeer buying consumers (women) are also among factors contributing to more rapid growth.

Instrumentation and automatic controls integrating batch processing equipment significantly increase production capacity by decreasing the time required to produce each batch. Such systems permit programed regulation of process variables (temperature, pressure, flow, level, relative alkalinity), by means of a centralized control panel graphically indicating progress through each cycle. One industry expert estimates that the typical plant of 1975 will be producing beer at about twice the speed of the typical 1965 brewery, provided that the whole plant is engineered on the higher speed basis. Rapid brewing cycles are achieved by shortening nonproductive time (for example, in pumping liquid between tanks and in filtering out solids during the brewing) and by integrating each processing step.

Blending systems which keep raw material flowing at rates which reproduce a preset formula, regardless of slowdowns in one of the component lines or in a pump which is feeding materials, are now being introduced. Progress



Brewery workers check cooking control board and brew kettles in an advanced brewery.

of the blending is indicated on a central control panel.

Mechanized cleaning systems are being installed in a few advanced plants. Automatic detergent spraying equipment, installed in brew kettles, fermenters, and wort and holding tanks, eliminates manual scrubbing. The hazards of serious accidents, which can occur when workers enter tanks too soon after use and are overcome by heat or gasses, or are splashed by caustic washing compounds, are greatly reduced. Hand scrubbing of coolers, pasteurizers, bottle washers, and other brewery equipment is minimized by new chemical cleaners and additives, and by improved equipment design.

Advanced wort cooling equipment with automatic cleaning is replacing coolers which required 1 to 1½ hours of hand scrubbing for every 12 hours of operation. The new coolers are safer because they are entirely enclosed. They occupy only one-tenth the space needed for earlier systems, and air conditioning the space is no longer necessary. In one brewery where two coolers are operated constantly at 330 barrels an hour, cleaning labor requirements have been cut from two men per shift to one man per shift.

Advances in packaging methods and materials-handling equipment are eliminating labor. Faster packaging lines and more automatic cleaning, filling, and labeling machines are being installed to improve labor productivity in packaging, where about three-fourths of all production workers are employed. Mechanical equipment now being installed automatically lifts bottles from cartons onto conveyors leading to washing machines; a worker monitors the line to prevent backup and breakage. In some installations, cartons of returnable bottles are removed from trucks mechanically onto conveyors, where sensing machines sort and divert the cartons onto specialized lines for each bottle size.

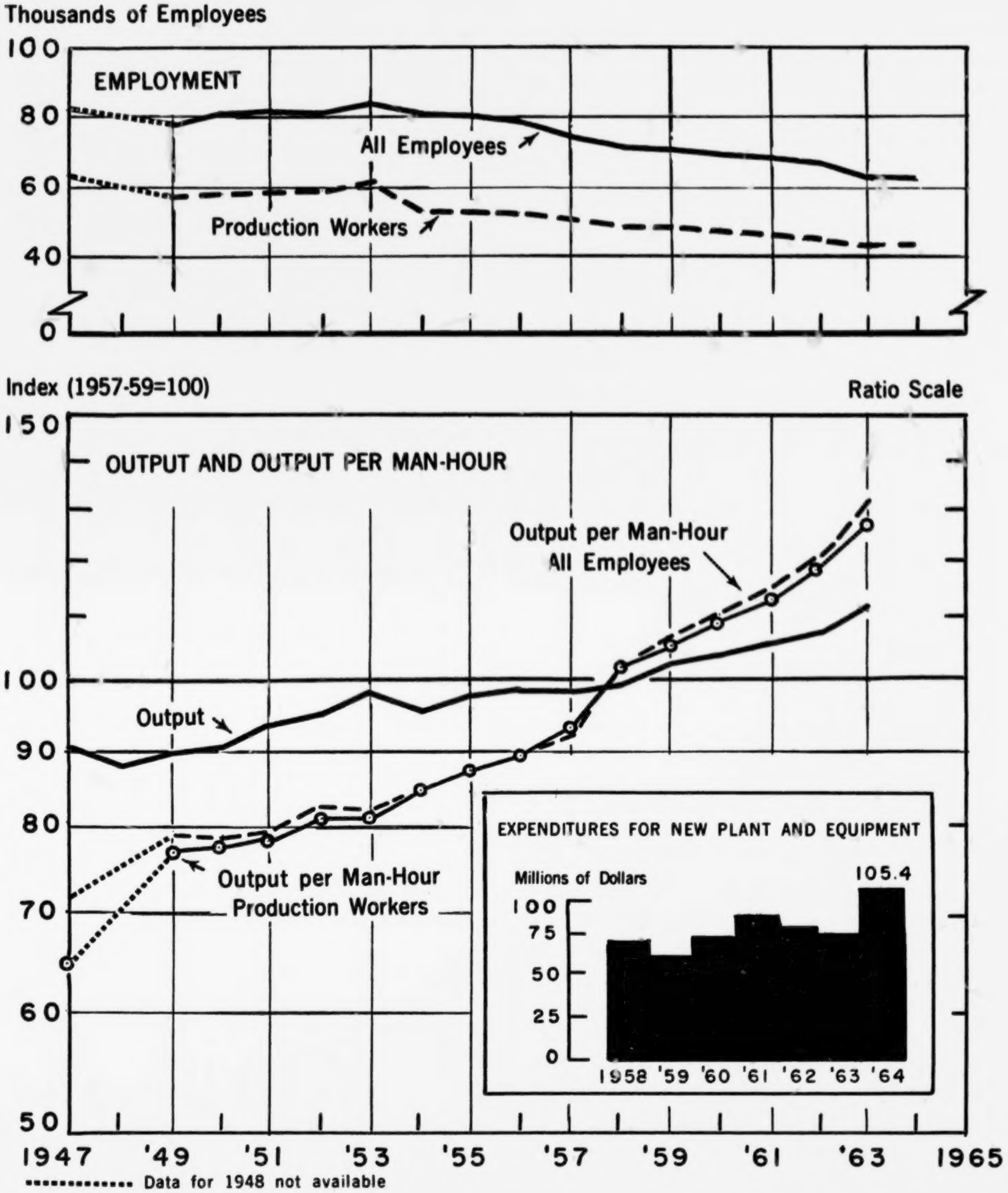
Small improvements eliminate unpleasant job duties. For example, label sludge, formerly removed by hand from bottle washing machines at the end of each shift, is now drawn off by extractors; washing machines remain in continual operation. The declining proportion of bottles which are returned, washed, and reused, reduces the amount of cleaning work required to prepare packages for filling.

Filtering beer just before it is packaged eliminates pasteurizing filled bottles and cans. The very fine membrane filter removes yeast and other organisms, preventing further fermentation and spoilage in the stored package. One of the several types of filters available was developed as a result of defense research for the Army Chemical Corps. At least 10 brewers now are producing some filtered packaged beer, although this filtering method was introduced only recently. The filtered product, which requires no refrigeration in storage, may be labeled "draft," even when it is marketed in cans. Costs of filtering systems are estimated to be $12,000, about one-twentieth the cost of pasteurizers of the same capacity. However, aseptic filling equipment and sterile containers become necessary. Another method of sterilizing beer prior to bottling is bulk pasteurization, which deactivates or destroys spoilage organisms by holding the beer a short time at high temperatures under pressure. Aseptic filling equipment is necessary.

Research is now being conducted on fermentation-retarding additives, which could eliminate both filtration and pasteurization. Approval by the Food and Drug Administration would be required before they could be used in production.

Continuous processing, from mash mixing through fermenting, is claimed to result in significant operating and capital savings. As of 1965, only one brewery had been designed and erected for continuous processing. When continuous flow processing is substituted for batch methods, large holding vats and tanks are eliminated. Raw materials flow steadily through various cooking, filtering, and cooling stages without worker intervention. It is claimed that output of poor or spoiled beer is virtually eliminated, and cooking under high temperatures improves the yield of malt, sugar, and hops. Process time, and cleaning and maintenance work, are reduced. Construction costs for a two-story continuous processing plant are 25 percent lower than conventional five-story breweries of equal capacity.

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN MALT LIQUORS



Sources: Employment and expenditures, Bureau of the Census; output and output per man-hour, Bureau of Labor Statistics.

On the other hand, improvements in batch processing may reduce the advantages of continuous processing. Some companies, for example, are adopting some parts of the continuous process (such as continuous fermentation) in existing plants, but not installing the entire continuous process. Some experts believe that the possibility of difficult biological problems, which do not arise in batch processing, where equipment is cleaned after each use, may be a major obstacle to rapid adoption of continuous processing.

Widespread adoption of the beer concentration process, over the next 5 to 10 years, appears unlikely. These partial freezing processes remove most of the water content of beer after fermentation but before final finishing. The concentrate thus formed can then be reconstituted at the same brewery in which it is made or elsewhere at small local plants by adding water and carbon dioxide. Concentration has been reported to reduce the aging (or lagering) process from weeks to days or hours, eliminate refrigeration in storage in some cases, and cut space requirements drastically. Developers of the process claim that a batch method brewery could utilize its capacity more fully and mitigate seasonal production peaks by increasing its production during slack winter months, storing the production as concentrate (since it can be stored longer without spoiling), and reconstituting and selling stored concentrate during the peak season.

Shipping concentrate in bulk from a central plant to local reconstitution and bottling plants could cut jobs in trucking, railroad transportation, and wholesaling. Packaging jobs in local plants could be increased, while packaging employment in the concentrate-producing centers might be reduced.

Under 1965 Internal Revenue Service regulations, a producer of concentrate may ship it only to its own reconstitution and bottling plants (breweries), or may export it. The reconstituted product is subject to the same tax as other beer and may be mixed with other beer, except the bottled final product must be labeled as made from concentrate. As of 1965, no company in the United States was commercially producing beer concentrate.

Some brewers' associations and unions of brewery and trucking workers who may be adversely affected by widespread adoption of the concentration process are supporting legislation that would prohibit domestic shipment of beer concentrate outside the plant which produces it.

Expenditures for new plant and equipment increased from $72.9 million in 1958 to $105.4 million in 1964. The introduction of prefabricated warehouses and plant additions, and the compact nature of newer processing equipment, may allow substantial economies in future construction. In one prefabricated plant, for example, construction costs were reduced by one-third for a 250-barrel-a-day plant.

The total number of breweries dropped from 252 to 190 between 1958 and 1964. Small local breweries accounted for most of this decline, while large national brewers increased their share of the market. Net plant losses between 1958 and 1963 were greatest in Middle Atlantic and East North Central States, which produce 55 percent of malt liquors. Current new plant construction is located chiefly in the West and Southwest.

Manpower Trends and Outlook

Output per man-hour probably will continue to rise at a fairly rapid rate. Output per all employee man-hour increased at an average annual rate of 2.6 percent during the 1947–57 period. The growth rate between 1957 and 1963 was sharply higher—6.2 percent per year. Output per production worker man-hour increased 3.7 percent annually from 1947 to 1957, and 5.5 percent annually from 1957 to 1963.

Employment decline may continue, but at a moderated pace. Employment (Census) declined from 82,500 in 1947 to 77,400 in 1957, or 0.6 percent a year. By 1964, it had fallen to 61,900, declining at about 3.1 percent a year after 1957. Production workers dropped by 2.2 percent a year between 1947 and 1957; and continued to fall, at 2.8 percent a year, between 1957 and 1964. Although nonproduction workers (including truck-drivers) represented 23

	Average annual percent change
All employees	
1947–57	–0.6
1957–64	–3.1
Production workers	
1947–57	–2.2
1957–64	–2.8
Output	
1947–57	.8
1957–63	2.2
Output per all-employee man-hour	
1947–57	2.6
1957–63	6.2
Output per production worker man-hour	
1947–57	3.7
1957–63	5.5

percent of all employees in 1947, they had risen to 34 percent of the total by 1957, and were slightly below that level in 1964.

Occupational shifts will continue. Continuous processing may reduce brewhouse jobs, which comprise about 10 to 20 percent of the work force in a highly instrumented batch brewery. A kettleman controls operations from a centralized control panel where the instruments are displayed. A brewmaster is still required to control quality. Among packaging workers, further mechanization will continue to displace materials-handling employees. New varieties of packaging, however, may offset this trend to some extent.

Some Issues and Examples of Adjustment

Provisions are being introduced in pension plans to encourage early retirement. One contract, covering 5,000 workers, was revised in 1964 to provide "retirement incentives," up to May 31, 1966: a monthly payment of $100 in addition to the pension, for 3 years, to workers retiring at age 65; and a higher monthly payment to workers retiring between 60 and 65. Another contract, covering 4,800 workers, permits retirement at age 60 after 10 years of service, and requires retirement at 65.

An Employment Security Fund was established in one 1964 contract covering several thousand employees. It provides supplementary unemployment benefits of up to $100 a week (including unemployment compensation when paid) for up to 26 weeks for laid-off employees. Employer contributions, amounting to 20 cents per hour worked by permanent bottlers and 10 cents per hour worked by other employees, support the fund.

Longer vacations increasingly are being adopted to shorten worktime per year and mitigate seasonality. Paid vacations recently were extended by a number of major contracts, in some cases to 7 weeks after 20 years of employment; 8 weeks after 25 years. Through some contracts, efforts are made to mitigate the job impact of seasonality. For example, vacations are scheduled for slack winter months; a few contracts require that all but 2 weeks be taken in the off season. Others limit the proportion of employees who may be off during late spring and summer months. Ten to 11 holidays are specified in some major brewery contracts, which further shorten the work year; the holidays granted may sometimes be "banked" and taken with pay during slack seasons.

Work rules in some contracts are varied according to layoff conditions. In one contract covering several thousand employees at several breweries, apprenticeship entry and the assignment of specific tasks to some job titles are limited when regular employees are on layoff. Some major contracts establish minimum numbers of workers on such equipment as pasteurizing, bottle-filling, or palletizing machines; truck crew sizes and loads may also be specifically limited. Work requirements and "manpower adequacy" are sometimes specifically made arbitrable. In addition, at least two major contracts provide for joint union-management committees to resolve work load and scheduling problems as they arise. Such committees also function in other plants, even though not included as a contract item.

Selected References

"Automates Solids Handling," *Food Engineering*, January 1963, pp. 70–71.

"Beer Brews Better With Controls," *Instrumentation*, Vol. 13, No. 3, 1960, pp. 4–6.

"Beer Concentrates Procedures Clarified," *American Brewer*, September 1963, p. 30.

"Continuous Beermaking Makes Commercial Debut," *Chemical Engineering*, Jan. 4, 1965, pp. 18–20.

Fallon, H. T. "Tele-Processing System Links National Plants Together," *Modern Brewery Age*, pp. 32–33.

"Fastest Beer-Can Line," *Modern Packaging*, May 1962, pp. 116–120.

Feller, Karl F. *Report to the Delegates of the Thirty-Sixth Convention of the International Union of United Brewery, Flour, Cereal, Softdrink and Distillery Workers of America, AFL–CIO–CLC*, Baltimore, Md., August 1961.

Ford, Kenneth. "Beer: Larger Markets, Tougher Competition," *Printers Ink*, Feb. 12, 1965, pp. 44, 46–48, 50.

Griesedieck, Joseph. "The Next Ten Years in the Brewing Industry," *Brewers Digest*, December 1964, pp. 18–19.

International Labour Organisation, *Health and Safety in the Food Products and Drink Industries*. Tripartite Technical Meeting for the Food Products and Drink Industries, Geneva, 1963.

Malick, E. A. and G. H. Dale. "Studies of Concentrated and Reconstituted Beers," a paper presented at the Annual Convention of the American Society of Brewing Chemists, New York, N.Y., May 6, 1964.

Malick, Emil A., Lee H. Boyer, and Robert O. Dunn. "The Optimising of Brewery Output Through Continuous Beer Concentration and Computer Programing." Reprint from the October 1963 issue of the *Brewers Digest*, pp. 2–4 and 6–14.

U.S. Congress, House of Representatives, Committee on Ways and Means. *Hearings on Whether the Process of Manufacturing Beer Concentrate Will Necessitate Amendments to the Internal Revenue Code*, 88th Cong., 1st sess., Nov. 5, 1963, Washington, 127 pp.

"World's Fastest Beer Bottling," *Modern Packaging*, April 1963, pp. 180–183.

"Wort Cooling at Pabst," *Modern Brewery Age*, December 1964, pp. 34–35.

The Tobacco Products Industry (SIC 211, 212, 213)

Summary of Outlook Through 1970

High rates of increase in output per man-hour in both cigar and cigarette and other tobacco products manufacturing are expected to be maintained as changes in technology continue to be introduced. Major labor-saving technological developments include expanded use of reconstituted tobacco sheet, more automatic, electronically controlled processing equipment, a wider variety of mechanized materials-handling devices, and increased instrumentation. Employment is likely to continue to decline in the manufacture of cigars and cigarettes and other tobacco products as gains in output per man-hour exceed those in output.

Outlook for Technology and Markets

Total output of tobacco products is expected to continue to expand. Output of tobacco products (BLS index) increased at an average annual rate of 3 percent between 1957 and 1963, compared with a rate of increase of 1.2 percent from 1947 to 1957. Production of cigarettes and other tobacco products (chewing tobacco, smoking tobacco, and snuff) grew 3.7 percent a year during 1957–63, more than two and one-half times the annual rate of increase from 1947 to 1957. From 1957 to 1963, output of cigars grew 1.5 percent annually and 1 percent a year from 1947 to 1957. Primarily because of the population gain in the smoking age group (the number of persons 18 years and over will grow at an average rate of 1.5 percent a year from 1965 to 1970), total output of tobacco products is expected to continue to increase. Rates of output growth, however, are difficult to estimate because of the uncertainty of future consumer reaction to the issue of smoking and health.

Expanded use of reconstituted tobacco sheet is expected in cigar and cigarette manufacturing. This product is essentially a continuous sheet of tobacco made from a mixture of finely ground natural leaf materials and adhesives. It is being substituted widely in place of natural leaf as a cigar binder and to a limited though increasing extent, as a cigar wrapper. This development affords substantial savings in material requirements since broken leaves and leaf trimmings as well as whole leaves are utilized in the manufacture of tobacco sheet. Also, unlike natural leaf, uniformity of dimension and composition permits nearly complete consumption of tobacco sheet in its use as cigar binder and wrapper.

The greater adaptability to mechanization of tobacco sheet, compared with natural leaf, also permits substantial savings in labor requirements. For example, use of tobacco sheet makes possible elimination of the manual binder laying operation and the manual wrapper laying operation required when making cigars from natural leaf. In addition, the tedious, labor-consuming process of removing the tobacco leaf rib is no longer necessary.

Tobacco sheet has also been developed for use in the manufacture of cigarettes. Shredded and combined with natural leaf, tobacco sheet permits substantial material savings in cigarette making by utilizing otherwise unusable tobacco.

Improvements in processing equipment continue to increase efficiency in cigarette manufacturing. Equipment with electronic controls, automatic loading and unloading devices, and faster operating cycles is resulting in reduced processing time and unit man-hour requirements from tobacco processing to finished packaging. Unloading attachments (accumulators) for filter and cigarette-making machines, for example, can eliminate the job of hand collection, increasing substantially the overall efficiency of these operations. Latest available cigarette-making machines, incorporating such features as automatic filter attaching devices, are at least 50 percent faster than those of 10 years ago and are capable of producing as many as 2,000 perfectly finished cigarettes every minute. A cigarette-packaging machine, now being introduced, is adaptable to an integrated flow system of production and can produce 65 percent more packaged units than machines presently in use.

Equipment for production of cigars is becoming increasingly mechanized. Faster speeds, increased numbers of machine controlled functions, and combination of formerly separate operations in all types of production equipment —particularly cigarmaking machines—are among the advances. The introduction of automatic accumulators on cigarmaking machines, for example, eliminates the task of manually collecting finished cigars. Another cigarmaking machine features a device to attach mouthpieces to cigars automatically, with no reduction in rate of output. Attachments to cigarmaking machines for automatic feeding of tobacco sheet for both binder and wrapper eliminate two manual operations and, in one machine model, can increase output up to 20 percent.

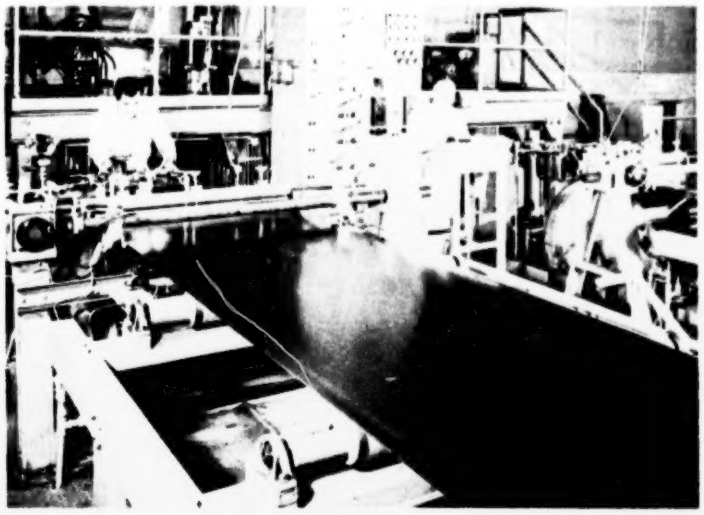
Fully automatic machines for making cigars with tobacco sheet wrapper and binder in a continuous length, which is then cut automatically to desired cigar size (rather than traditional manufacture of cigars as individual units), are being developed and are expected to be installed by the larger cigar companies in the near future. The rate of output of these new machines is expected to be 35 to 40 times as great as that of equipment currently used.

Conveyor systems are reducing materials-handling requirements and improving process flow. Electronically controlled conveyors are being introduced to feed precise amounts of different cigarette tobaccos to automatic blending machines. Improved tobacco distribution systems, such as an electronically controlled pneumatic tube system, are being installed which automatically air-clean blended tobacco and maintain a predetermined amount of it at each of the cigarette-making machines. Labor savings are also being achieved in cigar and cigarette manufacturing through more widespread integration of several separate units of production equipment by means of conveyors. Full integration of the entire process—from tobacco preparation through final packaging—has been accomplished in only a few of the larger cigar and cigarette companies.

Instrumentation is expanding. Increased emphasis on improved product quality and production efficiency is resulting in the growing use of precision instruments in most of the production processes, principally in cigarette making. One electronic inspection device, used in conjunction with cigarette-making machines, checks the quality and weight standards of 2,000 cigarettes in less than 2 minutes, compared with the 3 to 4 hours required for hand inspection of the same quantity. Another device on filter-plug-making machines tests and measures automatically the diameter of the plugs as they are being made. Electronic devices used with packaging machines automatically detect packages with missing or defective cigarettes, foil, labels, or stamps.

Business applications of electronic data processing are becoming extensive. Computers—introduced into the industry during the past several years—are expected to be used increasingly for accounting, payroll, operations analysis, inventory control, and engineering functions. When in full service, a computer center recently established by one large cigarette firm is to link its offices, factories, and warehouses throughout the country.

Production of cigars in fewer but larger plants is expected to continue. This trend is due largely to the economies of large-scale production and to equipment costs associated with the continuing mechanization of the industry. Between 1947 and 1963, according to the Bureau of Census, the number of cigar manufacturing plants fell substantially—from 822 to 192. At the same time, average plant employment



Control line worker observes processing of reconstituted tobacco sheet used as binder and wrapper in automatic cigar manufacturing.

doubled, and the percentage of plants with fewer than 20 employees decreased from 77 percent to 57 percent. Further concentration of cigarmaking will probably take place as mechanization increases.

The cigarette industry, already highly concentrated, is expected to continue to consist of a relatively small number of large, highly mechanized plants. Located in Virginia, North Carolina, and Kentucky—cigarette manufacturing establishments totaled 14 in 1963; their average employment exceeded 2,500.

Research and development will probably increase. The cigarette manufacturers study such matters as the composition of cigarette smoke, smoke filtration, and production processes equipment. Cigar manufacturers also are engaged in substantial research on product development, manufacturing processes, and equipment development, particularly on improving the manufacture and utilization of tobacco sheet.

Capital spending is expected to increase. Expenditures for new plant and equipment in the total tobacco products industry were $50.3 million in 1964, rising irregularly from a level of $28.6 million in 1958. Investment in the cigarette and other tobacco products segment, which accounted for 85 percent of the total industry expenditures in 1964, also increased irregularly during this period. Expenditures in cigar manufacturing increased substantially in 1964 after declining steadily between 1958 and 1963. Emphasis on installing improved methods and equipment throughout the tobacco products industry and plans for construction of new, highly mechanized cigar manufacturing plants by several of the largest firms point toward a growth in expenditures over the next few years.

Manpower Trends and Adjustments

Productivity will probably continue to increase at a high rate. Output per all-employee man-hour and production worker man-hour for total tobacco products increased at average annual rates of 5.9 and 6.4 percent, respectively, between 1957 and 1963; these rates were about double the corresponding annual rates of 1947–57. In the larger segment of the industry, cigarettes and other tobacco products, output per man-hour for all employees and production workers increased at 3.1 percent and 3.5 percent a year, respectively, between 1957 and 1963—rates more than twice those of the earlier period. Increases in output per man-hour for all employees and production workers in cigar manufacturing between 1957 and 1963 reached the very high annual rates of 9.2 and 9.6 percent, respectively, after growing at the corresponding high annual rates of 5.1 and 5.2 percent from 1947 to 1957.

Employment is likely to continue to decline. Employment (Census data) for total tobacco products fell from 71,500 in 1957 to 62,900 in 1964, or at an average annual rate of 1.9 percent. Comprising 63 percent of the total industry employment in 1964, employment in the cigarette and other tobacco products segment rose at the rate of 0.5 percent a year between 1957 and 1964, following a decline of 0.1 percent annually from 1947 to 1957. During 1959–64, however, employment in this segment declined at an annual rate of 1.6 percent although output increased.

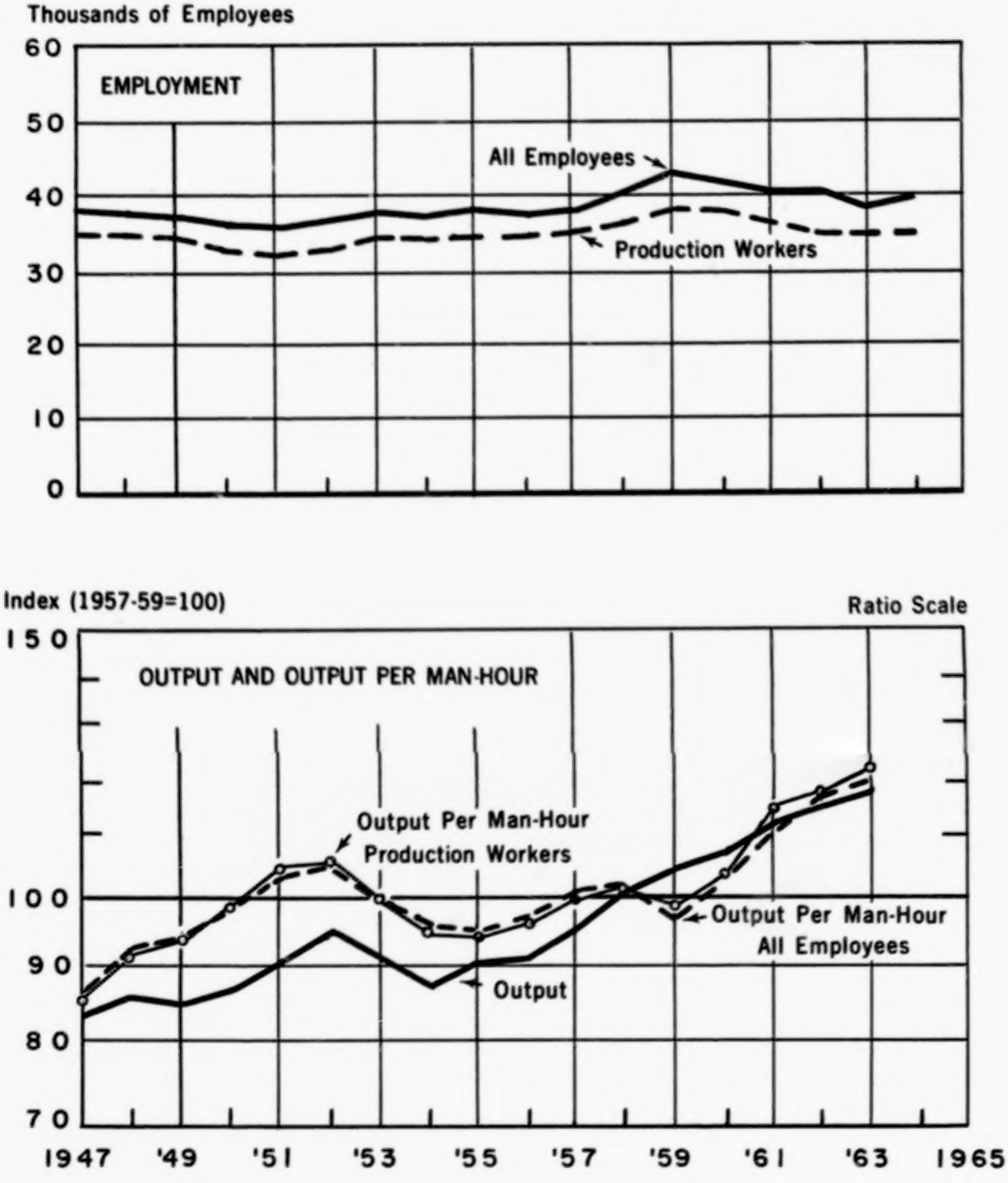
Cigar manufacturing employment declined at a rate of 5 percent a year between 1957 and 1964, exceeding the annual decrease of 3.5 percent during 1947–57. Because gains in output per man-hour are likely to continue to exceed those in output, a further decline in employment in both cigar and cigarette and other tobacco products is probable.

Continued change in occupational structure is expected. Production workers represent a relatively high proportion of all employees in tobacco products manufacturing, accounting in 1964 for 93 percent in the cigar industry and 89 percent in the manufacture of cigarettes and other tobacco products. These proportions are 2 percentage points lower than those in 1947.

Engineers, scientists, and technicians are increasing in relative importance, due to the continuing emphasis on improved mechanization, product development, and quality control. Employment in these occupations in all tobacco products manufacturing approximately doubled between 1950 and 1960.

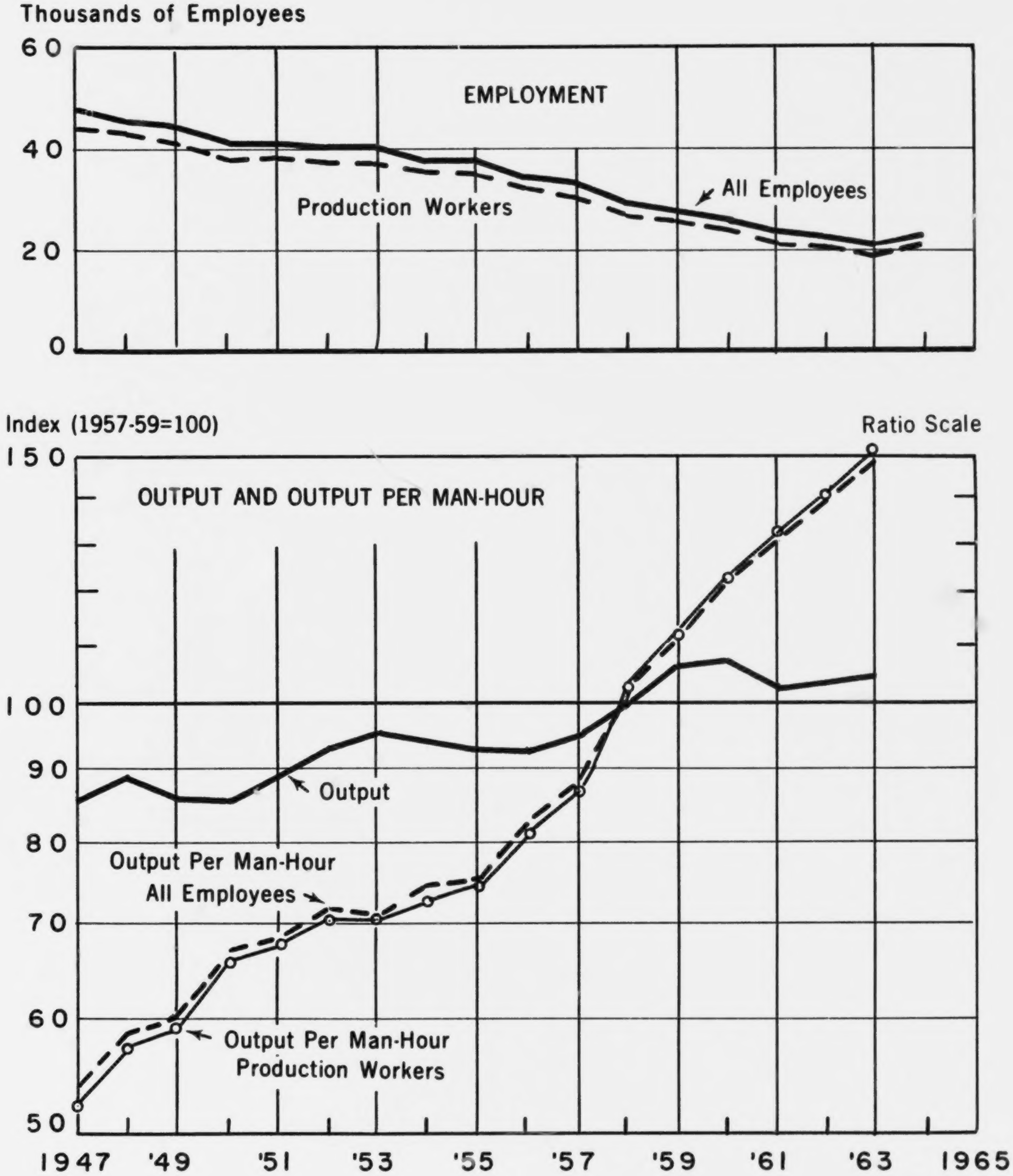
Increased mechanization may be expected to continue to alter man-hour requirements in

EMPLOYMENT, OUTPUT, AND OUTPUT PER MAN-HOUR IN THE CIGARETTES AND OTHER TOBACCO PRODUCTS INDUSTRY



Sources: Employment, Bureau of Census; output and output per man-hour, Bureau of Labor Statistics.

EMPLOYMENT, OUTPUT, AND OUTPUT PER MAN-HOUR IN THE CIGAR INDUSTRY



Sources: Employment, Bureau of the Census; output and output per man-hour, Bureau of Labor Statistics.

TOBACCO PRODUCTS (CIGARETTES, ETC.)

	Average annual percent change
All employees	
1947–57	–0.1
1957–64	0.5
Production workers	
1947–57	–0.1
1957–64	0.1
Output	
1947–57	1.4
1957–63	3.7
Output per all-employee man-hour	
1947–57	1.5
1957–63	3.1
Output per production worker man-hour	
1947–57	1.5
1957–63	3.5

TOBACCO PRODUCTS (CIGARS)

	Average annual percent change
All employees	
1947–57	–3.5
1957–64	–5.0
Production workers	
1947–57	–3.6
1957–64	–5.0
Output	
1947–57	1.0
1957–63	1.5
Output per all-employee man-hour	
1947–57	5.1
1957–63	9.2
Output per production worker man-hour	
1947–57	5.2
1957–63	9.6

production occupations. Introduction of more automatic equipment and more widespread use of tobacco sheet will probably reduce further the number of cigar machine operatives (including the wrapper and binder layer operators). These workers accounted for 30 percent of production worker employment in cigar manufacturing establishments in 1964, compared with 34 percent in 1961. Further reduction in the number of cigarette-making machine operators and "catcher girls" (manual collectors of finished cigarettes) are also likely. Employment in these two occupations declined from 30 percent of total production worker employment in cigarette manufacturing in 1960 to 28 percent in 1965.

Increases in employment of machine adjusters and electronic maintenance men, however, may be expected as more complex, electronically controlled processing equipment is introduced. The employment of inspectors also may continue to rise. In cigarette manufacturing in 1965, adjusters, inspection personnel, and maintenance employees accounted for 18 percent of total production worker employment, compared with 13 percent in 1960. These employees comprise a relatively smaller but growing group in cigar manufacturing; they accounted for 6 percent of all production workers in 1964.

Retraining programs are underway to meet changing skill requirements. Classroom and on-the-job instruction for workers engaged in the operation of new production equipment is being intensified by many cigarette manufacturers. Extensive instruction of office and management personnel in computer use is also being undertaken. In the cigar industry, various skilled and semi-skilled workers are being retrained under the Manpower and Development Training Act of 1962. In 1964, 28 on-the-job training programs were established in various cigar plants; nearly 400 workers were to receive additional training in such occupations as maintenance mechanic and wrapper layer.

Selected References

Technological Developments

Alexander, Tom. "Millions of People Just Won't Smoke Cigars," *Fortune*, September 1965, pp. 165–167 ff.

Morgenbesser, David. "Cigaret Makers Push Diversification Plans," *The Journal of Commerce*, Nov. 10, 1964, p. 5.

"Brown and Williamson Plans $26 Million Expansion," *Western Tobacco Journal*, August 1965, p. 30.

"Philip Morris Launches Advanced Computer System," *Tobacco*, Apr. 17, 1964, pp. 11, 14.

Roberts, John. "Molins at Milestone Seeks New Worlds to Conquer," *Tobacco*, Feb. 7, 1964, pp. 14, 24.

"Cigarette Maker," *Tobacco*, Apr. 3, 1964, p. 16.

Manpower Trends and Adjustments

Industry Wage Survey, Cigar Manufacturing, April–May 1964 (BLS Bulletin 1436, 1965), 31 pp.

Industry Wage Survey, Cigarette Manufacturing, July–August 1965 (BLS Bulletin 1472), 16 pp.

Stetson, Damon. "Tampa Undergoing Bumpy Transition as a Cigar Center," *The New York Times*, Mar. 3, 1964.

The Textile Mill Products Industry (SIC 22)

Summary of Outlook Through 1970

Interest in plant modernization is stronger in this industry than at any time in the last 50 years. Capital expenditures for plant and equipment are expected to continue to rise. The push for technological improvements is being stimulated by intensified efforts to meet foreign and interfiber competition, an improved financial position, and the emergence of larger companies run by managers with more professional training.

Major laborsaving technological developments being introduced include faster, larger capacity machines, mechanized materials handling, and continuous processing. Although output is expected to increase over the next few years, employment will probably continue to decline, but at a more moderate rate than in the past 10 years. The emphasis of job requirements is shifting from machine tending and duties calling for manual dexterity to machine watching and patroling.

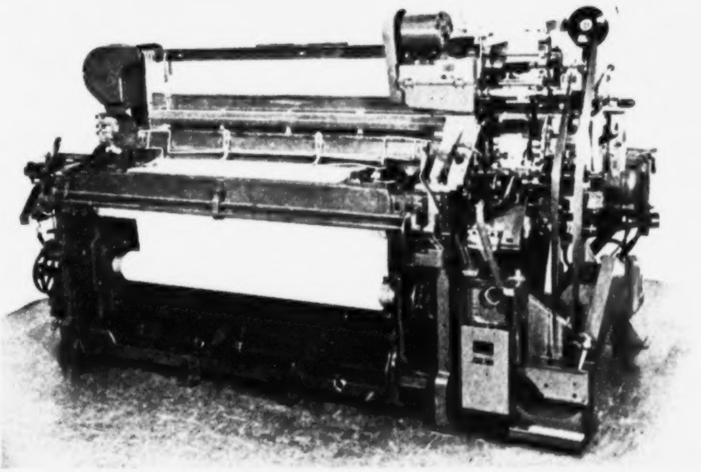
Outlook for Technology and Markets

Output will continue to rise at a moderate rate. Output, according to the Federal Reserve Board, rose 3.5 percent annually from 1957 to 1964, considerably above the 1.3 percent rate from 1947 to 1957. Production, measured in terms of fiber poundage consumed in textile mills, reached a new high of 7.8 billion pounds in 1964, increasing at an annual rate of 3.2 percent from 1957 to 1964, whereas from 1947 to 1957 mill fiber consumption had decreased slightly. The growth rate was considerably higher from 1960 to 1964—4.6 percent annually. The strongest growth areas of fiber consumption have been knit goods, tufted carpets, seamless hosiery, and manmade broadwovens.

Textile output over the next 5 to 10 years probably will rise at or above the 1957–64 rate of growth because of increasing disposable income and population growth, with a greater proportion of teenagers and members of new family formation age groups, the major textile consumers. In addition, textile output in the near future may be affected by the degree to which defense procurement increases. On the other hand, expansion of imports may dampen the growth rate.

Industry probably will continue to operate at high rates despite an increase in productive capacity. The rate of operation (according to McGraw-Hill surveys) rose from 80 percent in 1957 to 96 percent in 1964—the preferred rate in the industry. At the same time, productive capacity has also increased. More intensive machine utilization over a 3-shift day and higher productivity per machine have more than compensated for retirement of marginal mills and obsolete equipment. In 1964, for example, only slightly less cotton cloth (1.3 percent, square yards) was produced than in 1954, but with 18 percent fewer active spindles and 19 percent fewer active looms.

Synthetic fibers will continue to increase their share of the market. Continuing growth in production of manmade fibers and fabrics results in deeper market penetration, with lower unit labor requirements than natural fibers. For example, manmade filament yarn does not require conventional preparatory mill operations through spinning. Manmade fibers (cellulosics and noncellulosics) made up 41 percent of all mill fiber consumed in 1964 (based on pound



High speed loom is equipped with automated filling-handling system that eliminates several steps in textile manufacture

data), compared to 29 percent in 1957. Two-thirds of the increase was in noncellulosics (including nylon, polyester, acrylic, spandex and olefin) which more than doubled their share of all fiber consumption from 8 percent in 1957 to 18 percent in 1964.

The outlook is for a continued increase in noncellulosic consumption, with estimates of growth ranging from 5–10 percent annually from 1964 to 1975. As a percentage of total consumption, noncellulosics will increase sharply by 1975. On the other hand, expanded research on cotton, wool, and cellulosic fiber is strengthening their competitive position. Legislation reducing cotton prices to world market levels has also given cotton a new boost relative to synthetics, lessening the pressure to switch to synthetics.

By 1970–75, total manmades will probably make up more than 50 percent (in pounds) of all fiber consumed in textile mills compared with 41 percent in 1964. Actually, manmades' share of the total fiber market is even greater when measured in terms of the end product rather than in fiber poundage consumed in the mill because the number of square yards of cloth produced from a pound of manmade fiber is greater than the amount produced from a pound of cotton or wool fiber.

Faster machine speeds with larger packages are a major factor in reducing unit labor requirements. New carding machines operate at more than 4 times the speed of 10 years ago, drawing machines at 6 times the speed. Spindle speeds were 10,000 r.p.m. in 1950, are 13,500 today, and 20,000 r.p.m. are now possible. Winding speeds are at least double that of 10 to 15 years ago. Conventional loom speeds increased 25–50 percent in the past 15 years and shuttleless looms may soon double the speed of weaving. Machine output of hosiery and other knitting equipment, due to multiple feeds, also is rising very significantly. Carpets are now produced mainly by high-speed tufting machinery, rather than by the slower weaving process.

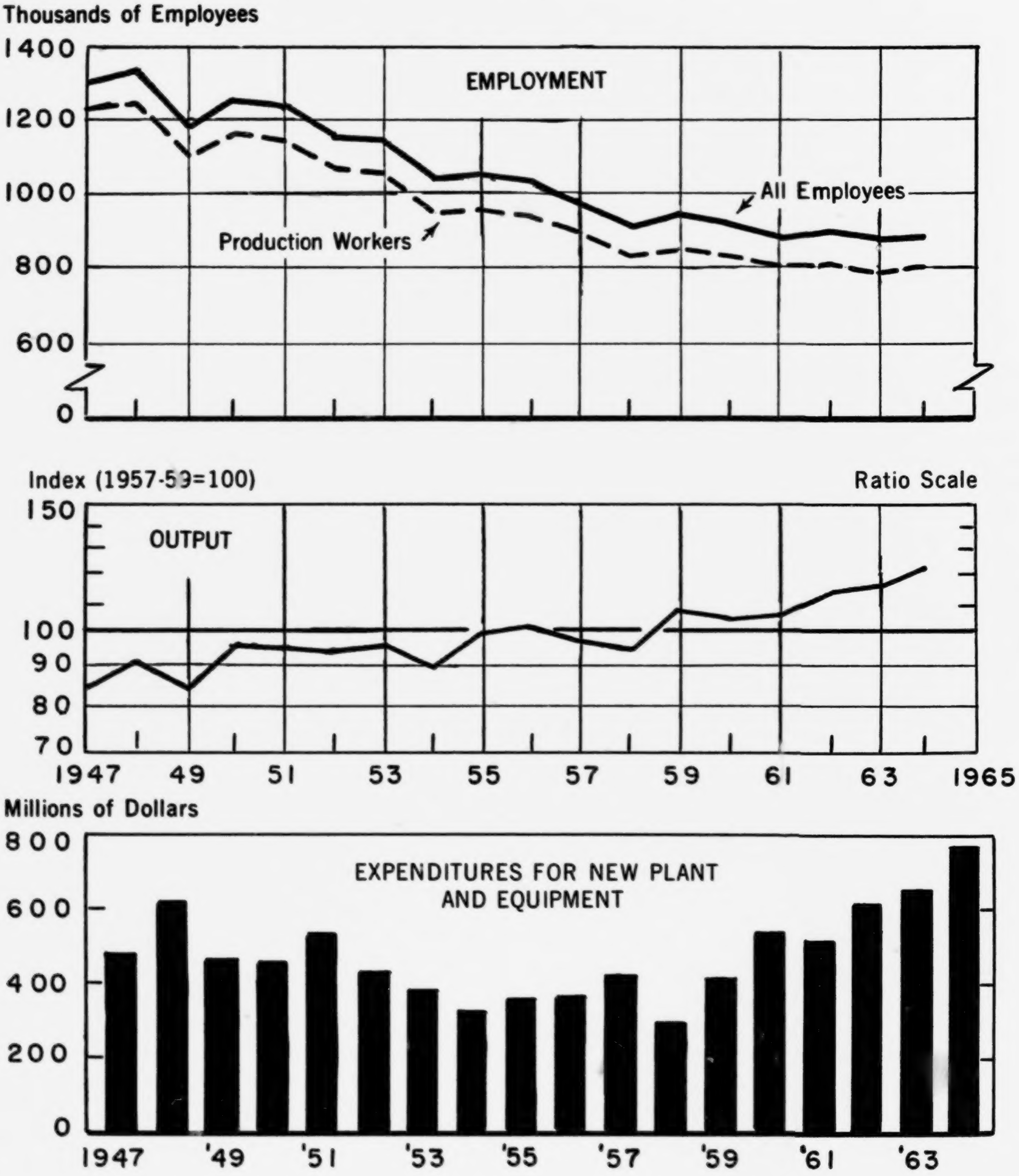
Faster machines are accompanied by larger packages (laps, bobbins, and cans of stock), resulting in lower unit labor requirements. Labor savings can also be achieved as relatively fewer machines replace the older models. In one modernized cotton mill, for example, 206 carding machines recently replaced 600 earlier models, and they deliver stock to an 85-pound can compared with the previous 24-pound can.

Improved conveyor systems and pneumatic chutes may improve process flow and reduce materials-handling operations. More widespread adoption of mechanical transfer of goods between the many discrete textile processes is significant, since materials handling comprises 5 to 15 percent of production costs. Improved powered conveyors, hoists, monorails, tramrails, and forklift trucks are being utilized increasingly at all steps, from raw material to finished product. Mechanized handling is particularly important in improving process flow in the older multistory mill, and in handling heavy machine packages, which are twice as heavy as earlier packages. For example, automatic conveyor systems now utilized in the newest mills pick up the 80 to 90 pound lap and deliver it to a lap storage indexer, from which it automatically moves to the carding machines, as needed. Pneumatic stock conveyance, a more advanced method which moves stock by air, also greatly increases productivity but is costly and still limited in use.

Built-in maintenance reduces maintenance requirements. Central lubrication and sealed antifriction bearings are examples of built-in maintenance which results in less downtime, lower unit costs, and improved quality. It is claimed that roller bearings on new drawing frames require oiling only once every 3 years during overhaul compared with once a week on older models. Some of the newest spinning frames have gearing enclosed in oil baths, eliminating almost all lubrication and maintenance.

New model looms can be built with central lubrication covering 75 percent of the necessary points to be oiled. In one of the mills built most recently, all production machines are equipped with an automatic lubrication system in which oil enters through lines in the floor and is pumped to lubrication points on each machine once every minute. Only a few mills are utilizing central lubrication so far, but the outlook is

EMPLOYMENT, OUTPUT, AND CAPITAL EXPENDITURES IN TEXTILE MILL PRODUCTS



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board; expenditures, Securities and Exchange Commission.

for gradually increased adoption of this technique of saving maintenance labor.

Automated devices for cleaning and for atmospheric control are gaining industry acceptance. Cleaning may constitute as much as 20 percent of total labor costs in yarn mills. High speed machinery intensifies the cleaning problem. Cards, for example, which produce 40 pounds an hour create considerably more lint and fly than cards producing 20 pounds an hour. One solution increasingly being adopted is the installation of suction devices on the machine at points of discharge. In addition, a traveling monorail cleaner, which automatically blows residue off machine frames, vacuums the floor, and pneumatically carries the waste to the waste room, is increasing mill efficiency.

A potentially useful process, still limited to a few of the newest plants, is the system of total air cleaning. This system forces the air down from overhead ducts, carrying the lint laden air with it, to ducts under the floor. The air is filtered of waste and returned to the overhead ducts. Plant efficiency is increased, but the system is said to be too costly for the average mill.

Electronic instrumentation still is limited, but growing in importance. Stop motion devices, and continuous automatic inspection, recording and controlling instruments which replace visual scanning or other slower methods of inspection, reduce downtime and permit more efficient quality control. An electronic device, for example, used in the winding operation, photoelectrically detects defects in the yarn and automatically stops the winder for their removal.

Some of the newer electronic devices activate machine changes when a defect is detected. For example, yarn thickness is controlled by a photoelectric cell on a drawing machine which detects the difference in light passing through the yarn and signals an electromagnetic clutch which adjusts the machine accordingly.

Mechanical and electronic counters and central monitoring systems are being utilized increasingly for cost and quality control. An electronic monitoring system, for example, which records the performance of every loom on a central console, visually and in printed reports, is now economically feasible, but will be limited to the newest mills.

Computers are used by large companies for data processing and are being extended to control finishing processes. According to a 1965 McGraw-Hill survey of large companies, 56 percent of textile companies responding reported computer installations. Major uses included accounting, inventory control, and production planning.

The first computer control system for use with a production process was installed in 1964 in a finishing plant. Uses in finishing involve continuous analysis of processing data for control of continuous bleaching and dyeing operations, and dye color matching to determine the cheapest combination of dyestuffs to match colors. Until quite recently, color matching was achieved largely by trial and error.

New textile products (less than 10 years old) in 1973 may be 35 percent of total sales. In 1963, according to McGraw-Hill estimates, they constituted 22 percent. Fiber and product innovations such as easy-care finishes, stretch yarns, laminated and coated fabrics, and nonwoven fabrics may open new markets or displace more conventional fabrics.

Some nonwovens (needlepunch and bonded) bypass spinning, weaving, and knitting processes and have much lower labor requirements than woven fabrics. A very recent development is the successful use of the needlepunch process for blanket manufacture, which may result in its application to other products. Bonded nonwovens (fiber fused by heat or chemicals), used for clothing interlinings, disposable medical items, and vinyl coated products, are also broadening their markets, but are not expected to exceed 5 percent of textile production by 1970.

Progress is being made toward the goal of continuous automatic manufacture, but this system may be limited to specialized plants. Consolidation of two or more processes is a long-term development which has reduced significantly the number of operations. One of the most important developments is an automatic winding attachment to the loom which eliminates quilling as a separate process, greatly reducing labor requirements. Perhaps as many as 10 to 15 percent of all looms now have this attachment, primarily for use with coarser yarn, and the proportion will increase.

A more advanced system of continuous manufacture, in use in Japan, is being introduced for the first time into one or two mills in the United States, now under construction. This system integrates bale opening through carding (eliminating picking) into one continuous system and links together roving, spinning, and winding operations, utilizing automatic bobbin doffing machinery. Automatic doffing (removal of full bobbins), one of the most time consuming operations in a conventional mill, is now commercially feasible in the United States. Claims of expected increases in output per man-hour in this type of mill range from 70 percent to 100 percent above the conventional mills. Flexibility, however, is reduced and therefore this system probably will be best suited to mills with highly specialized production. By 1970, such automated continuous spinning mills still will be rather limited.

Plant and equipment expenditures reach new highs. It is estimated that, in 1965, textile mills invested over $1 billion, almost two and one-half times the amount invested in 1957. In the last 5 years, investment increased following 12 years (1949–61) of fairly low investment. Expectations are that, in the next 5 years, annual investments will exceed current high levels.

The proportion of current expenditures for new plants and plant expansion is much greater than in the past. The capitalization ratio of one of the newest mills (built in 1964) approximated $50,000 per employee, compared with $6,000 to $10,000 for older mills. In 1958, 70 percent of expenditures went into modernization, 30 percent into expansion; in 1965 investment ratios were expected to be 55 and 45 percent respectively.

R&D expenditures will continue to increase over the next few years. According to a McGraw-Hill forecast, R&D outlays by textile and apparel firms will reach a peak of $54 million in 1974, compared with $36 million in 1964. Only $15 million was spent in 1957. In recent years, a number of large diversified corporations appeared—as a result of mergers and acquisitions—which have been better able financially to undertake long range research and development projects. As a ratio of sales, however, R&D expenditures by the industry are relatively small. Textile and apparel companies engaging in R&D spent 0.5 percent of their net sales on R&D in 1963. In addition, however, substantial outlays were made by chemical companies for synthetic fiber research, by machine companies for machine development, and by the U.S. Department of Agriculture for natural fiber and fabric research.

Manpower Trends and Adjustments

Employment probably will continue to decline over the next 5 years, but at a moderate rate. Mill shutdowns and layoffs in the early postwar period brought employment down to 981,100 in 1957, from the 1947 near-high of 1.3 million, a rate of decline of 2.7 percent annually. In 1964, employment stood at 891,100, a decline of 1.4 percent annually from 1957. Major factors responsible for this long-term trend included declining exports, expanding imports, and changing technology. The period, 1961–64, was the first relatively stable period since the postwar peak; employment declined only 0.1 percent annually. Expanding textile demand over the next 5 years may offset, to some extent, the effect of reduced unit labor requirements and mill shutdowns, so that the rate of employment decline may be moderate.

The production worker ratio has been decreasing steadily but is still considerably above the ratio for all manufacturing. In 1964, production workers accounted for 89 percent of all

	Average annual percent change
All employees	
1947–57	−2.7
1957–64	1.4
Production workers	
1947–57	− 3.1
1957–64	−1.5
Output	
1947–57	1.3
1957–64	3.5

employees, compared to 94 in 1947 and 91 in 1957. As modernization moves ahead, this ratio will probably continue to decline.

Technological changes affect all types of textile occupations. Requirements for operators will continue to be cut back significantly by faster machines, larger packages, etc. These occupations, including the major groups of spinners and weavers, account for about two-thirds of all textile jobs. Installation of new high-speed cards and spindles, in one mill, for example, reduced requirements for card tenders by 25 percent and spinners by 30 percent.

Unskilled labor, only a small proportion of total jobs, will continue to be reduced by improved materials handling and mechanized cleaning and oiling devices. Some newly modernized mills report reductions of 25 percent in unskilled jobs over the past 5 years. In some new mills, not a single person is employed to haul material.

Mechanization of cleaning will reduce tasks previously performed by a machine tender, freeing him for more skilled duties. For example, with the newest system of total air cleaning, a card tender's cleaning duties occupy 10 to 15 percent of his time instead of the 65 percent spent in conventional mills.

Skilled maintenance jobs are also reduced by built-in maintenance features and reduction in number of machines. Only one picker fixer, for example, is required to service 14 new pickers; on older models one was required for 10.

Greater need is expected for technical personnel. The demand for engineers and technicians is increasing. An air-conditioning system in a large mill, for example, may require 7 to 8 technical employees. The larger mills employ instrument mechanics so that immediate qualified servicing can be available. More quality control and waste control engineers will also be required in the future.

New machinery requires operators to spend more time machine watching and patroling. The operator's job is becoming one of machine watching, rather than machine tending. Automatic picker machines, installed in only a few mills today, for example, eliminate the operator's two major functions of weighing and doffing, but he must continue to patrol the lines of machines to detect malfunctioning, etc. The spinner's functions—creeling, piecing-up broken ends, and cleaning—remain unchanged, but they need to be performed less frequently, permitting the worker to oversee more machines. Larger packages, for example, reduce creeling and new efficient high precision machines require less piecing-up of yarn. Similarly, automatic doffing will substantially alter the doffer's job content. Instead of manually doffing full bobbins and replacing them with empty ones, the doffer now will start the automatic machine and oversee the machine's operation. Although operators' duties are shifting from operations requiring manual dexterity to the patroling function, many industry experts believe that the highly complex textile machinery requires a more responsible employee.

Greater emphasis is being placed on formal training. More formal training programs for operating and maintaining equipment are being instituted, replacing traditional methods of learning on the job as an assistant. Textile machinery manufacturers now provide more training programs, particularly for maintenance men and technicians. Loom fixers, for example, may be trained for 3 weeks at the loom factory. With machinery manufacturers' cooperation, mills may maintain training equipment and qualified personnel within their own premises.

Selected References

Technological Developments

Dockray, George H. "The Systemated Mill," *Textile Industries,* February 1965, pp. 59–66.

Enrick, Norbert Lloyd, Editor. *Industrial Engineering Manual,* Pt. II, Systems, Procedures and Controls, January 1962, Southern Textile Methods and Standards Assn., pp. 105–167.

Goldberg, J. B. "Textile Research Achievements in 1964," *Textile Industries,* January 1965, pp. 83–94; February 1965, pp. 129–136.

"The Mill of Tomorrow," *Textile World,* May 1964, pp. 48–113.

Howell, L. D. *The American Textile Industry,* U.S. Department of Agriculture, Economic Research Service. November 1964, 146 pp.

Wheeler, Willard C. "Marketing, Key to Success in Textiles," *Modern Textiles Magazine,* January 1965, pp. 44–52.

"Yarn Manufacturing Today: Is Automation's Big Push Underway?," *Textile World,* June 1965, pp. 46–59.

Manpower Trends and Outlook

Barkin, Solomon. "The Effect of Increased Productivity on the Labour Force and its Deployment in the United States Cotton Textile Industry," *Productivity Measurement Review,* November 1964, pp. 39–57.

Industry Wage Survey, Wool Textiles, June 1962 (BLS Bulletin 1372, July 1963), *Cotton Textiles, May 1963* (BLS Bulletin 1410, August 1964), and *Synthetic Textiles, May 1963* (BLS Bulletin 1414, August 1964).

The Apparel Industry (SIC 23)

Summary of Outlook Through 1970

Despite recent trends toward larger firms, larger capital expenditures, and development of automatic equipment, apparel manufacturing will probably remain one of the least mechanized of the manufacturing industries. Major sources of productivity increases are expected to continue to be the wider use of such management techniques as improved work methods, more efficient work distribution, and improved plant layout. The future may see greater use of bonded fabrics and increasing utilization of new techniques to produce garments that can retain their press. Expanding production will probably lead to continued growth in employment levels.

Outlook for Technology and Markets

Moderate growth in production is foreseen. Apparel production (based on Federal Reserve Board data) increased at an average annual rate of 4.8 percent from 1957 to 1964, compared to 2.7 percent per year from 1947 to 1957. Expanding population and increasing volume of consumer expenditures are expected to lead to continuing growth in demand. However, rising imports—almost tripling in dollar value from 1957 to 1964—will probably fill a portion of this demand.

Mechanization will continue to be hindered by nonstandardized production. The apparel industry is composed, for the most part, of a large number of small firms with little capital, producing numerous styles, sizes, and types of clothing, usually in small lots. Of the 28,000 establishments in 1963, about 55 percent had fewer than 20 employees, and about 77 percent had fewer than 50 employees. Because of short, nonstandardized production runs and frequent style changes, extensive mechanization of the manufacturing processes continues to be difficult and in some cases uneconomical. The prevalent manufacturing system—the manual moving of a stack of individual garment parts through a series of individual operations, performed primarily on manually operated machines—will continue to be widely utilized, with only minor modifications foreseen in the near future. The industry is expected, therefore, to remain highly labor intensive.

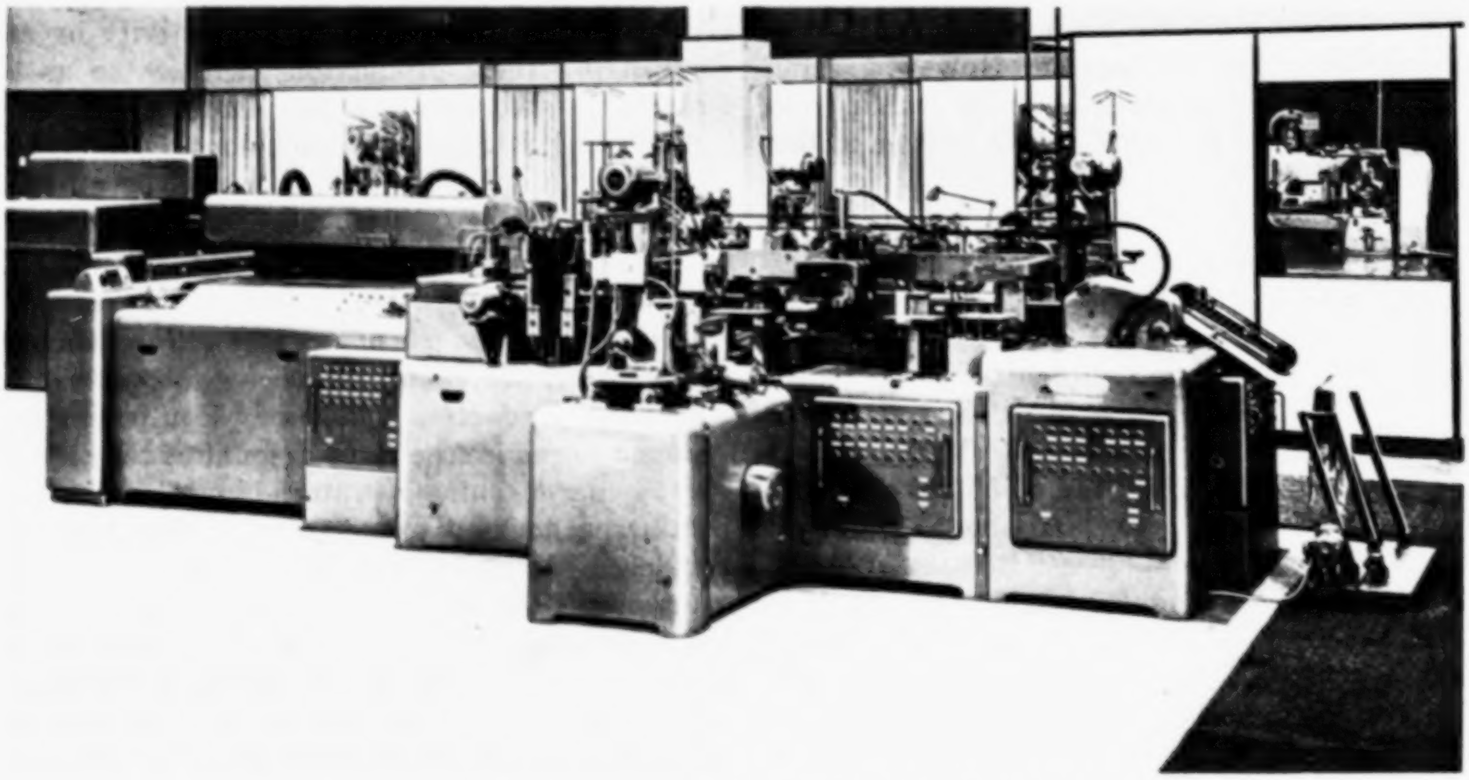
Technological change is likely to be more rapid among large-scale producers of standardized types of clothing. Firms making shirts, pajamas, underwear, work clothing, and similar staple goods, produce standardized goods for inventory as well as for orders, enabling long production runs for which mechanized equipment can be economical. These firms, which tend to be larger than average, are among the most mechanized in the industry and are expected to continue to adopt improved equipment to raise their productivity.

Production engineering techniques are expected to continue to be the major means of increasing productivity. Time study methods, improving the arrangement of equipment for a single operation and improving the workflow of an entire production process, afford significant labor savings. Many manufacturers have continued to gain increases in productivity by rearranging their production facilities so as to divide the work into a large number of very small, simple operations, each done by an operator using a single purpose machine, permitting the work to be routed more efficiently from operation to operation.

More widespread use of work handling aids and machine attachments is expected to continue to increase production efficiency. Equipment designed to reduce the large amount of time spent by sewing-machine operators in positioning and adjusting tasks is expected to be adopted more widely. Machines such as needle positioners, automatic thread cutters, and parts stackers can increase productivity up to 50 percent in the operations affected. In addition, hundreds of small, laborsaving sewing-machine attachments are expected to continue to be used for such operations as elastic fastening, pleating, and hemming. High speed sewing machines, thread trimmers, garment finishers, and automatic buttonhole machines are also likely to be utilized to an increasing extent. Time savings from each of these changes are very small, but the cumulative effect may be significant.

New processes for making garments that retain their press are becoming important. Utilizing improved chemically treated fabrics and heat curing techniques, manufacturers are expanding production of garments that can hold their shape through a number of washings. These new processes, widely used for men's and boys' trousers, and beginning to be used for shirts, are expected to be utilized for men's casual wear and work clothing and for women's sportswear in the near future. Many technical and production problems remain to be solved, but present methods consist of treating the fabrics at the textile mill and curing either by the textile mill before the garment is manufactured (precure) or by the apparel firm after manufacture (post-cure). Precure techniques are being utilized mainly for the light fabrics used for shirts; post-cure methods are more applicable for heavier fabrics such as those used for trousers. Apparel firms utilizing the post-cure process are required to use special ovens or high temperature presses to cure garments. Although the purchase of this expensive equipment is generally limited to large firms, small firms can subcontract out the curing operations. "Durable press" processes are utilized presently mainly for garments made from cotton-synthetic blended fabrics. Research is underway to apply similar techniques to other fabrics. Increased production worker man-hours may be required for the manufacture of garments utilizing "durable press" processes because of the additional operations needed.

Fabric-to-fabric bonded materials and electronic fusing of seams may lead to decreased unit labor requirements. Production of garments using bonded materials is increasing rapidly. Consisting of two fabric layers or two fabrics with a thin urethene foam layer in between, bonded together by fabric finishing firms, the use of these new materials reduces sharply the amount of cutting and sewing needed for manufacture of a garment. For example, an apparel manufacturer using a lining bonded to an outer fabric has to cut and sew the parts of a garment only once. Using the traditional unbonded materials, cutting and sewing of the



Transfer machine recently introduced automatically manufactures the complete left front of men's shirts.

lining and the outer fabric entail separate operations.

The electronic fusing of seams in garments made from synthetic fabrics, still in the pilot stage, would eliminate sewing operations entirely. This revolutionary development probably would reduce substantially the unit labor requirements in some areas of apparel manufacture.

New cloth cutting and patternmaking techniques are being utilized. Die-cutting machines are being used presently by a small number of firms to replace hand methods of cutting garment components, resulting in significant labor savings per unit. This method of cutting may become more widespread in the future. New pattern grading equipment, which produces a number of different size copies of a master pattern at the same time, has led to substantial productivity increases in this operation. New pattern marking systems, which use photographs of miniaturized patterns to preplan the marking of actual size patterns, are also being used increasingly. These miniaturized marking systems minimize cloth wastage and increase efficiency of marking workers by decreasing pattern layout time. Electric cloth-spreading machines, which, some users report, increase worker productivity as much as twofold in this operation, are expected to continue to replace hand methods in large firms.

Equipment combining a number of mechanized operations is being introduced, primarily for staple goods manufacturing. One of the most significant recent developments—a unit for making complete shirt fronts—moves parts automatically between a number of different machines which combine positioning, thread cutting, assembling, and sewing operations. Composed of two transfer lines, this machine makes both the left and right front of a shirt simultaneously, attaches pockets and buttons, and makes buttonholes. This unit is claimed, by the manufacturer, to be able to produce shirt fronts more than five times faster than present methods. So far, only one major firm has installed this equipment.

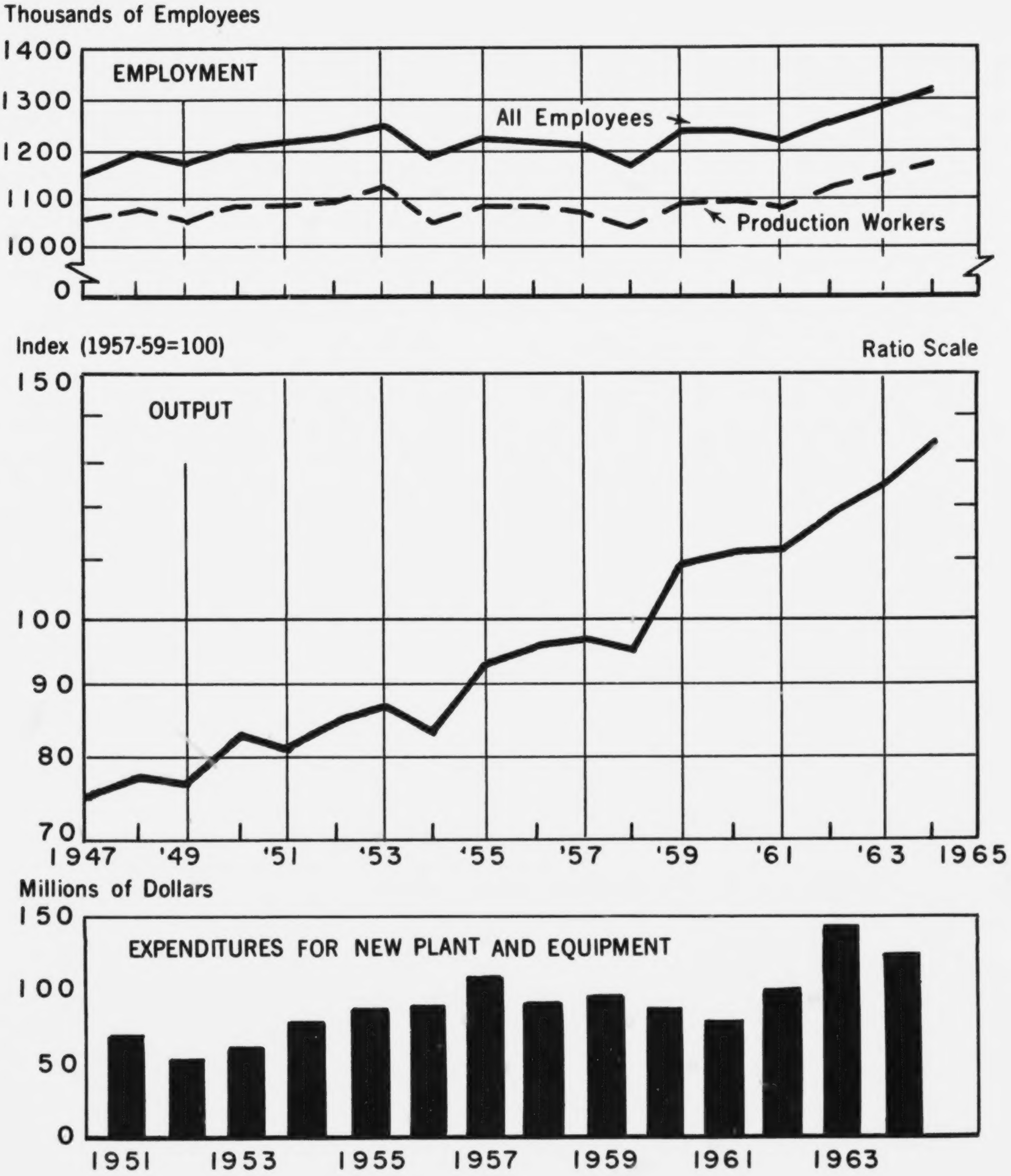
Another laborsaving machine that has been introduced recently is a unit for making complete dungaree pockets; it utilizes air jets to move precut parts through the machine and folds, lines, sews, and stacks the pockets automatically. Similar automatic equipment has been developed for making shirt cuffs and collar bands. Another innovation is a photoline tracing machine which runs a sewing head that can follow a pencil, ink, or tape pattern inserted in a control unit. Patterns can be changed in minutes, making this machine very flexible and adaptable for short-run production of small garment parts. Also, recently introduced is a highly flexible unit for sewing contour seams. This development utilizes a pivoting sewing head, guided by a photoelectric control, to follow the edge of the fabric. The high cost of most of these machines will probably deter their widespread use.

Use of conveyors in warehouses is expected to increase. A number of large multiplant firms have set up centralized garment distribution centers, utilizing conveyorized warehouses, to increase efficiency in distributing plant output. One firm increased its peak shipping capacity by 50 percent, while gaining a 32-percent total labor savings, with such a conveyorized order-processing system. Since fast, efficient distribution of apparel is of major importance throughout the industry, it is probable that conveyorized distribution centers will become increasingly prevalent in the future.

Utilization of computers primarily for business data processing is expected to grow. Many of the large apparel firms are using or are planning to install computers for business purposes. One of the most important computer uses is for sales analysis—allowing firms to adjust production quickly to the styles most in demand. In addition, computers are being used increasingly for order processing, inventory control, and accounting operations. For example, a multiplant firm significantly speeded up the preparation of order allocations and shipping tickets and now processes as many as 120,000 garments a day. Computers are also beginning to be used for manufacturing operations such as pattern grading and marking.

A Government-industry cooperative program is stimulating more technical research. The Na-

EMPLOYMENT, OUTPUT, AND CAPITAL EXPENDITURES IN THE APPAREL INDUSTRY



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board; expenditures, Bureau of the Census.

tional Bureau of Standards of the U.S. Department of Commerce initiated a program in 1963 to assist the industry in improving production processes, expanding collection and dissemination of technical information, increasing technical training of personnel, and assisting university research dealing with the apparel industry. In cooperation with the Apparel Research Foundation, a grant of $190,000, combining Federal and industry funds, was awarded to an engineering firm to develop equipment for the automatic conveying of multiple plys of fabric from stacks to the sewing machine, a process considered a bottleneck in the mechanization of sewing operations. The National Bureau of Standards is also testing mathematical techniques of computer simulation to assist the industry in improving production operations. The final objective of this joint effort is to develop a technical research program that can then be sustained wholly by the industry, which so far has spent little for research and development.

Expenditures for new plant and equipment are expected to increase. The industry's capital expenditures for new plant and equipment, among the lowest per production worker among all manufacturing industries, reached a peak of $143 million ($123 per production worker) in 1963 as compared to $107 million ($100 per production worker) in 1957, the previous postwar peak. One important factor likely to contribute to future growth in expenditures for new plant and equipment is the continuing trend in the industry toward mergers and acquisitions. This trend has resulted in a number of large firms, many of which are concerned with improving production efficiency through a continuing investment in modern facilities and equipment.

Manpower Trends and Adjustments

Employment will probably continue to increase. Total employment increased at an average annual rate of 1.1 percent from 1957 to 1964, compared to a 0.5 percent yearly rate of increase from 1947 to 1957. Production worker employment grew at about the same rates during these periods. Total employment and production worker employment reached their peak in 1964 —1,302,000 and 1,157,000 workers, respectively. These employment levels will probably continue to increase, since expanding demand for apparel is expected to outweigh productivity gains resulting from anticipated gradual changes in technology. Displacement problems that may occur because of technological change are expected to be minimized by the high labor turnover that has prevailed in this industry.

	Average annual percent change
All employees	
1947–57	0.5
1957–64	1.1
Production workers	
1947–57	.2
1957–64	1.1
Output	
1947–57	2.7
1957–64	4.8

The ratio of production workers to total employees is expected to remain substantially above the all-manufacturing average. It declined slightly from 90.7 percent in 1947 to 88.9 percent in 1964.

Slight changes in occupational structure are foreseen. The anticipated growth in demand for sewing-machine operators is expected to be affected only slightly by the adoption of new technology. Sewing-machine operators, mostly women, make up the largest occupational group in the industry. This occupation accounted, in 1963, for about two-fifths of the production workers making men's and boys' suits and coats, about one-half making women's and misses' dresses, and in 1961 for about three-fifths making men's and boys' shirts and nightwear, and about 70 percent making work clothing.

Production workers making styled garments, such as dresses, suits and coats, will be affected by the continuing shift from the tailor system, using many skilled hand operations, to the section system utilizing many sewing-machine operators. However, producers of the more expensive lines of styled garments—the least mechanized establishments in the industry—are expected to continue to utilize numerous hand occupations such as sewers, finishers, pressers, basters, button sewers, collar setters, and tailors.

Technically trained personnel may be needed for the new operations of curing and testing in the post-curing method of manufacturing "durable press" garments.

Unions and management are expected to continue to cooperate in the adoption of new technology. Both major unions, the International Ladies' Garment Workers' Union (ILGWU) and the Amalgamated Clothing Workers of America (ACWA) have assisted in the introduction of new equipment in unionized establishments, as part of a continuing program to promote sound business conditions in the industry. This policy of cooperation is stated specifically in the current master agreement between the ACWA and The Clothing Manufacturers' Association of the United States, covering most of the workers in the men's clothing industry. An example of cooperation between the ILGWU and manufacturers is the voluntary establishment in 1964, of a continuing labor relations committee by this union and a major women's sportswear firm. One of the topics of discussion on the agenda of this committee is the adoption of new production systems.

Labor-management contracts provide for measures to assure income protection and job and wage security. A recent BLS study including 52 major agreements in effect during 1962–63 in the apparel industry, showed that 35 agreements covering nearly 250,000 workers contained provisions for severance pay, layoff benefit, and supplemental unemployment benefit plans. Most of the contracts in force in mid-1965 between the two major unions and apparel manufacturers contained provisions assuring no reduction in wages and no loss of jobs because of technological change.

Selected References

On Technological Developments

Automatic Equipment and Work Aids in the Sewing Room, The American Apparel Manufacturers Association, Washington, D.C., 1963. 32 pp.

"Automation Showcase Section," *Southern Garment Manufacturer,* January 1965, pp. 56–73.

Case Studies of Productivity Increases in the Apparel Industry (unpublished), Kurt Salmon Associates, Washington, D.C., 1965.

"Centralized Warehouse Operation," *Apparel Manufacturer,* January 1965, pp. 20–21.

Friedman, W. F. "Modernized Distribution Center," *Apparel Manufacturer,* January 1965, pp. 18–19.

"Methods of Permanent Press Manufacturing," *Apparel Manufacturer,* January 1965, pp. 22–25.

"New Wrinkle in No Wrinkle Garb," *Business Week,* Nov. 21, 1964, pp. 34–36.

"Seventh Avenue Goes to Wall Street," *Forbes,* July 1, 1964, pp. 24–29.

"The Status of Automation," *Southern Garment Manufacturer,* January 1965, pp. 36–37, 46.

On Manpower Trends and Adjustments

Industry Wage Survey: Men's and Boys' Suits and Coats, October 1963, (BLS Bulletin 1424, January 1965). 100 pp.

Report of the General Executive Board to the 32nd Convention, International Ladies Garment Workers Union, May 12, 1965, Miami Beach, Fla., pp. 92–112.

The Pulp, Paper, and Board Industry (SIC 261, 262, 263, 266)

Summary of Outlook Through 1970

Output per man-hour probably will continue to increase in the pulp, paper, and board industry at relatively high annual rates as enlarged plans for modernization and expansion of production facilities are realized. Continuous digesters in pulp manufacturing; improved materials handling systems in woodhandling, finishing, and shipping operations; and more extensive instrumentation will be key technological innovations. New paper products may emerge from expanded research and development programs now underway.

Although employment is expected to increase through 1970, further gains in output per man-hour are expected to offset, to a large degree, employment increases arising from gains in output. But more engineers, scientists, technicians, marketing personnel, and skilled workers will be needed. Measures for retraining those already employed for new work and other ways of accommodating technological changes may receive more attention.

Outlook for Technology and Markets

Production is expected to continue to increase substantially. Production (BLS weighted index) increased at an average annual rate of 4.5 percent between 1957–63, slightly above the 4.2 percent average annual increase during 1947–57. The rate of expansion in output may be higher between 1965 and 1970, as growth in per capita consumption of paper and board products, population, and exports increase markets.

Materials handling systems are being further mechanized and expanded. Some unified conveyor systems which have been installed feature centralized control units which allow materials to move from step to step with a minimum of labor. For example, in a large paper mill, employing nearly 1,500 workers, replacement of an obsolete woodroom, staffed by 127 workers, with a new facility incorporating an extensive conveyor network, more than doubled output per worker in the operation.

Other innovations being installed in pulp and paper mills include highly mechanized paper roll handling systems which transport paper rolls with minimum of manual handling, and use of industrial TV systems to monitor log conveying, pulp washing, and other operations from remote stations. The increased productivity of high-speed papermaking machines being introduced may encourage further mechanization of materials handling to avoid costly production bottlenecks.

Installations of continuous pulping equipment (digesters) are increasing. Continuous digesters with automatic controls eliminate the intermittent flow of wood chips and manual starting and stopping of each batch of pulp. They have been found to lower labor costs in pulping by as much as 50 percent, steam requirements by 30 percent, and water needs by 10 percent. Moreover, fiber yield is substantially higher than in batch systems. Although batch processing will continue to be preferred by some mills, experts foresee major expansion in application of continuous digesters. In early 1965, they represented probably less than 5 percent of all pulping systems. By 1970, experts forecast that most new installations and major additions to chemical pulping capacity will probably involve continuous pulping equipment.

Technicians examine data provided by a computer control system installed on a paper machine.

Instrumentation and control systems are being improved and expanded. Spending for industrial instruments in the pulp and paper industry is rising: it was 45 percent greater in 1965 than in 1963. The trend is toward centralized control systems, whereby an entire operation is monitored on graphic panels by one or two employees stationed in air-conditioned rooms.

Advances in electronics are leading to new instrument applications. For example, beta gages are being used on paper machines, primarily to measure and control paper thickness thereby improving quality control. Other advances include microwave techniques for measuring moisture content of paper and magnetic flowmeters, first introduced in 1955, to measure and control pulp flow.

Electronic computers are being used in connection with process control on a limited basis. More than 20 pulp and paper mills had control computers in place or on order in early 1965. Further expansion is anticipated in the use of control computers. One large firm which installed a computer control system for a continuous digester anticipates savings of $250,000 annually because of increased output, higher yield, lower chemical consumption, and reduced maintenance. Computer control is also being applied to other major processes in the industry involving the wash plant, bleach plant, and paper machine. The extension of computer control will likely be a major factor in the projected rise in investment in controls from an average 3–5 percent of plant costs in 1964, to about 12 percent by 1970.

Although computer control systems have potential for improving quality control and productivity, some difficulties have been reported and at least two early users of computer systems have removed them from operation. Problems resulted from the use of inadequate instrumentation in support of the computer control system, failure to assign experienced process and instrument engineers to computer projects, and incomplete knowledge of the interaction of production variables.

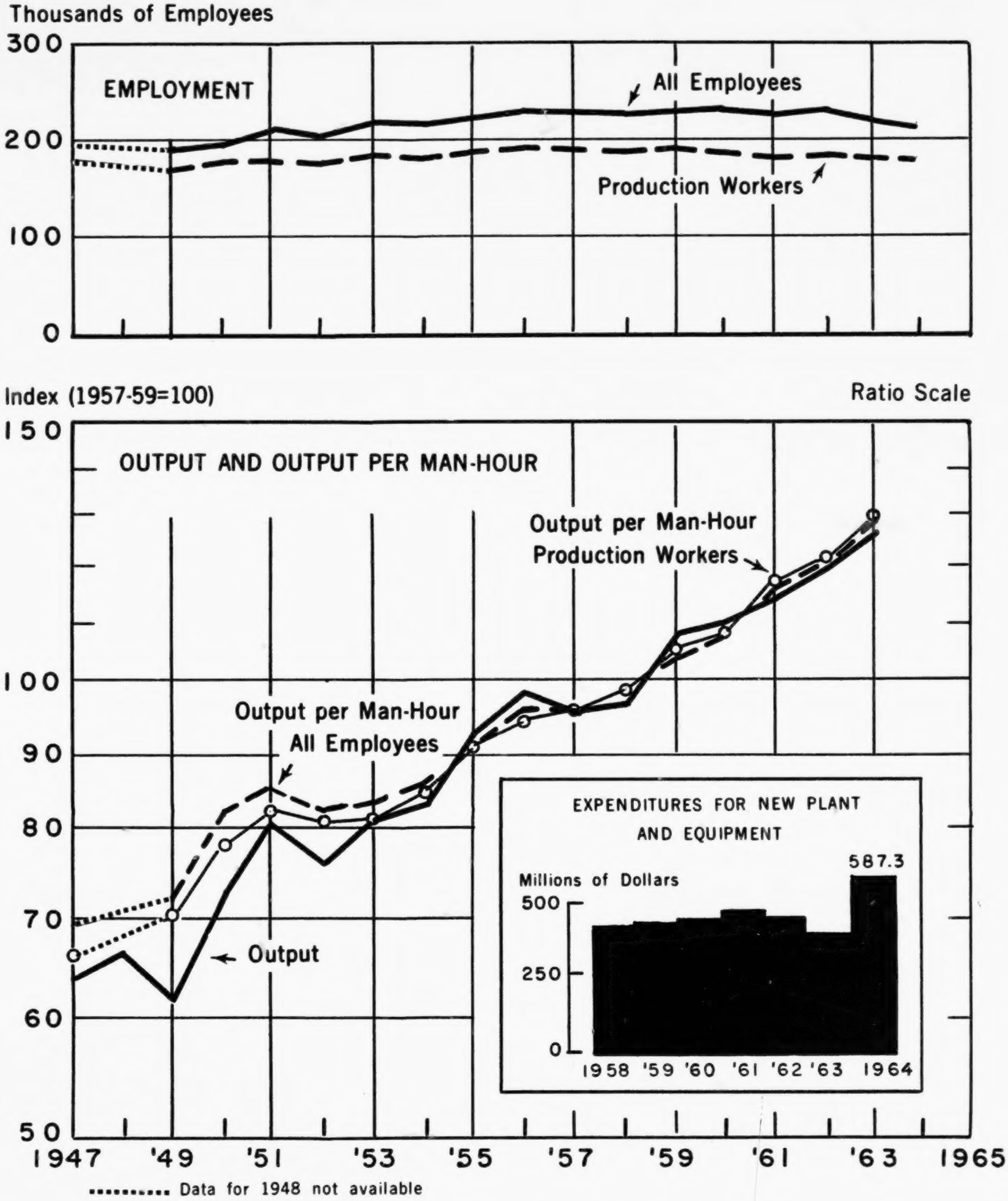
Semichemical pulping is growing in importance. This process—involving a relatively brief chemical treatment of chips, followed by mechanical separation of the fibers—permits higher yields from pulpwood than can be achieved in full chemical systems. Semichemical systems also utilize types of hardwoods readily available but previously little used in papermaking. Although semichemical pulp comprised only 9 percent of total pulp output in 1963, compared with 6 percent in 1953, wider use of such systems is expected and some experts predict that semichemical pulp may eventually rank second in total pulp production.

Use of wood residue for pulping is gaining in importance. Wood chips from sawmill residue, such as slabs and edgings, accounts for about 40 percent of all pulpwood consumed in some mills. A few mills, however, report using purchased chips almost exclusively, thereby achieving labor and capital savings in woodyard and woodroom operations. Although experts foresee further expansion in use of sawmill residue, they predict that an even faster growth in chip utilization will result as use of portable chippers and barkers becomes more widespread.

Research and development expenditures are increasing. According to the National Science Foundation, the paper and allied products industry (SIC 26 which includes firms manufacturing pulp, paper, and board, and converted products) in 1963 spent $71 million on research and development, or 45 percent more than in 1959. The number of R&D scientists and engineers in the paper and allied products industry rose from 2,000 in 1959 to 2,900 in 1964, and may number about 3,400 in 1968. Between 1965 and 1968, research and development expenditures, according to McGraw-Hill projections, may increase by 19 percent.

The development of new paper products, including combinations of paper with plastics and metals, is a major area of research and development. One leading firm has produced on a paper machine a nonwoven fabric with some of the characteristics of textiles. Another company is marketing products manufactured from waste bark, spent pulping liquor, and wood residue from sawmills. Some firms are building modern technical centers to concentrate present R&D activities and to carry out expanded research and development programs. Tech-

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN PULP, PAPER AND BOARD



Sources: Employment and expenditures, Bureau of the Census; output and output per man-hour, Bureau of Labor Statistics.

niques to reduce stream pollution are also being developed.

Investment for plant and equipment probably will continue to increase. Annual capital expenditures by the pulp, paper, and board industry have, in general, been increasing steadily since 1958, reaching a record $587 million in 1964. Forecasts indicate high levels of capital spending will continue through 1970 because of the substantial anticipated increase in demand. Funds are expected to be allocated equally for expansion and for replacement and modernization. Plants now under construction, some in new locations, will be an important source of new jobs.

Manpower Trends and Adjustments

Output per man-hour in the pulp, paper, and board industry probably will continue to increase at a relatively high rate—probably above 4 percent annually. Output per all employee man-hour increased rapidly at an average annual rate of 4.9 percent during 1957–63, substantially above the 3.4 percent annual growth rate during 1947–57. Output per production worker man-hour has been rising more rapidly —5.1 percent between 1957–63 and 3.9 percent between 1947–57. Over a longer period 1947–63, output per production worker man-hour rose at an average annual rate of 4.3 percent.

Employment will probably increase only slightly. Because of continued gains in output per man-hour, the projected increase in output may be handled without major increases in industry employment. Total employment in the pulp, paper, and board industry (Census data) was 220,936 in 1964, compared to 197,000 in 1947. The ratio of non-production workers to total employment probably will continue to rise as firms hire more sales, marketing, and related employees. The average weekly hours of production workers (excluding paperboard mills) rose slightly from 43.2 in 1958 to 44 in 1964. Average weekly overtime hours of production workers increased from 4.7 to 5.7—substantially higher than in manufacturing.

	Average annual percent change
All employees	
1947–57	1.4
1957–64	– .4
Production workers	
1947–57	.8
1957–64	– .7
Output	
1947–57	4.2
1957–63	4.5
Output per all-employee man-hour	
1947–57	3.4
1957–63	4.9
Output per production worker man-hour	
1947–57	3.9
1957–63	5.1

Skilled and technical workers are gaining in relative importance. Employment of engineers, scientists, technicians, and skilled workers is rising faster than that of other occupational groups. Scientific, technical, and marketing personnel will continue to gain in relative importance as firms expand research and development programs over the next decade. Skilled maintenance and repair workers will be needed in greater numbers to service more complex papermaking equipment. But experts foresee less rapid expansion in employment of semiskilled and unskilled workers, including helpers and laborers, whose employment is reduced as pulp and paper mills become more highly mechanized.

Significant changes in job duties are resulting from technological innovations. Mills which introduced materials handling equipment and continuous pulping equipment significantly reduced the number of workers who moved materials or manipulated machinery by hand, but created some new jobs for workers who were required to oversee a wider expansion of workflow, relate one processing step to another, and regulate operations by pushbutton control. For example, a sawyer at a mill which installed a highly mechanized woodroom now controls sawing operations from a control panel without direct manual intervention. After the changeover, the proportion that manual laborers comprised of total woodroom employment declined significantly, and the proportion of machine operators and tenders more than doubled.

Advance planning is easing the impact of technological change. The practice in adjusting to technological change in many mills is to provide advance notice of forthcoming technological innovations, to reassign workers displaced by mechanization to jobs elsewhere in the plant in accordance with seniority provisions of collective bargaining contracts, and, when necessary, to provide workers with new job skills through retraining. Some mills have hired temporary employees to carry on operations as employees whose jobs were scheduled to be eliminated were reassigned elsewhere within the plant.

In-plant training programs are preparing workers for new jobs. Plant studies disclose that workers reassigned to newly created positions generally are retrained by company personnel and by representatives from the equipment supplier to operate new equipment. Where changes involve mechanization of materials handling, training is typically brief and provided on the job. The introduction of a new continuous pulping system, however, requires more elaborate training involving lectures, classroom instruction, and training manuals. Maintenance employees are also at times assigned to a formal training program to acquire skills needed to maintain modern equipment.

Selected References

On Technological Developments

Adams, David S. "New Trends and Patterns in Material Handling in the Finishing Room," *Paper Trade Journal,* Dec. 9, 1963, pp. 36–40.

"Continuous Digester in Manufacture of Paper Pulp," *Automation* February 1964, pp. 83–86.

Fox, E. C. "Computer Control of the Continuous Digester at Gulf States," *Paper Trade Journal,* Nov. 4, 1963, pp. 36–39.

Guthrie, John A. and Armstrong, George R. *Western Forest Industry: An Economic Outlook.* Published for Resources for the Future, Inc. (Baltimore, Johns Hopkins Press, 1961), pp. 95–123.

Luke, David L. "Pulp and Paper," *American Enterprise: The Next 10 Years,* Martin R. Gainsbrugh, editor (New York, The Macmillan Co., 1961), pp. 217–222.

Slatin, Benjamin. "Long-Term Forecasts for the Pulp, Paper and Paperboard Industry," *Paper Trade Journal,* Dec. 16, 1963, pp. 36–43.

Van Derveer, Paul D. "Instruments, Automation and the Pulp and Paper Industry," *Paper Trade Journal,* May 20, 1963, pp. 39–42.

On Manpower Trends and Adjustments

Adams, Wallace L. "Apprenticeship Training for Paper Machine Crews," *Paper Industry,* August 1964, pp. 383–384.

Impact of Technological Change and Automation in the Pulp and Paper Industry (BLS Bulletin 1347, 1962), 92 pp.

International Brotherhood of Pulp, Sulphite, and Paper Mill Workers. *Automation —Economic Implications and Impact Upon Collective Bargaining* 2d ed., June 1964, 452 pp.

International Brotherhood of Pulp, Sulphite and Paper Mill Workers. *Selected Clauses in Collective Bargaining Agreements in the Pulp and Paper Industry Related to Automation and Technological Change* (Oct. 13, 1964), 62 pp.

Phillips, Paul L. "Automation in Pulp and Paper," *I. U. D. Digest* (Industrial Union Department, AFL–CIO, summer 1957), pp. 35–40.

The Printing and Publishing Industry (SIC 27)

Summary of Outlook Through 1970

Output of printed materials is expected to continue to increase at relatively high rates. As recent technological developments become more widely adopted, productivity in key operations, particularly in composing room and bindery processes, will increase significantly. More widespread use of faster printing presses; offset lithographic printing; gravure printing; and methods of coded tape, computer-aided, and photographic typesetting are among the major changes underway.

Employment is expected to increase. Training programs will continue to be expanded to provide skills needed for new processes and equipment. The pace of introduction of new technology and measures for adjustment are expected to be among the important issues of labor-management negotiations.

Outlook for Technology and Markets

Production is expected to continue to increase. Demand for books, newspapers, and other printed media will rise as population, educational level, leisure time, and per-capita income continue to increase. Output, according to the Federal Reserve Board index, increased at an average annual rate of 3.2 percent between 1957 and 1964—compared with 3.6 percent between 1947 and 1957. According to several industry projections, printing output in 1980 will be more than twice that of 1960, continuing at about the 1947–64 rate.

Offset lithographic printing is gaining in importance, particularly in small- and medium-size firms. The shift from letterpress to offset lithographic printing is increasing because of its potential for fast setup, adaptability to the photocomposition process, and improving photographic reproduction. Capital expenditures in 1965 by the industry as a whole for offset lithographic presses are estimated to be more than four times greater than for letterpresses.

In early 1965, 24 percent of the about 10,000 daily and weekly newspapers were printed on offset presses. Industry sources state that by 1970, most of the weekly and smaller daily newspapers in the United States with less than 25,000 circulation probably will be printed on offset presses. Many smaller newspapers are finding it economically advantageous to contract or consolidate their printing in trade shops or "printing centers."

In commercial printing plants, the number of offset presses increased more than ninefold between 1954 and 1963. Further applications of this equipment throughout the printing industry depends on such factors as the supply of skilled craftsmen, advances in offset versatility, and competition from improved letterpress equipment.

Tape-controlled linecasting (metal typesetting) machines are being improved and used more widely. By early 1965, for example, 800 of the Nation's 1,763 daily newspapers had converted to tape-controlled (automatic) linecasting machines. Substantial additional applications in newspaper and other printing plants by 1975 are expected. More than 10,000 keyboard operated machines (teletypesetters) are being used throughout the printing industry to prepare the coded paper tapes needed to actuate these laborsaving linecasting machines. Once produced, tape data can be transmitted by wire to printing plants located in different cities, reperforated on other tapes automatically, and used to operate automatic linecasting machines. Faster automatic linecasting machines, some 50 percent more productive than earlier models, are being marketed to keep pace with the larger volume of tapes being produced by high-speed electronic computers.

Photocomposition (phototypesetting) is expected to gain substantially in importance. This process utilizes the principle of setting copy to be printed on film or photosensitive paper rather than being set in metal type. The operation of phototypesetting equipment is generally similar to that of its metal typesetting counterparts, enabling metal typesetting workers to operate them with minimum retraining; and, like improved metal typesetting equipment, phototypesetting machines feature automatic, paper-tape operations.

At the present time, phototypesetting is used primarily in composition of newspaper advertisements, and the number of newspapers using such equipment has nearly tripled between 1957 and 1962. Phototypesetting equipment currently being developed is expected to produce significantly more lines of type per minute and to use more styles and sizes of type. Because of the potential economies of increased versatility and speedups of 50 times or more in production capability, prospects for more widespread use of phototypesetting throughout the printing industry over the decade are very favorable.

Electronic computers are being used more extensively to speed the preparation of control tape that guides typesetting machines. In this process, copy is first converted to coded tape by conventional methods, but the operations of spacing the type into the exact length of the printed line and hyphenation of words are omitted. The tape is then fed into an electronic computer programed to perform these operations automatically. The computer also prepares a new control tape containing both the new and the previously prepared instructions for the operation of tape-controlled linecasting and phototypesetting machines. The computer justifies lines and hyphenates words significantly faster than when performed manually by operators on conventional tape perforator equipment. In early 1965, more than 130 electronic computers were installed or on order for this use. In the newspaper industry, computers in use or on order more than tripled between 1963 and 1964. The outlook for increasing use of computers throughout the printing industry is very favorable.

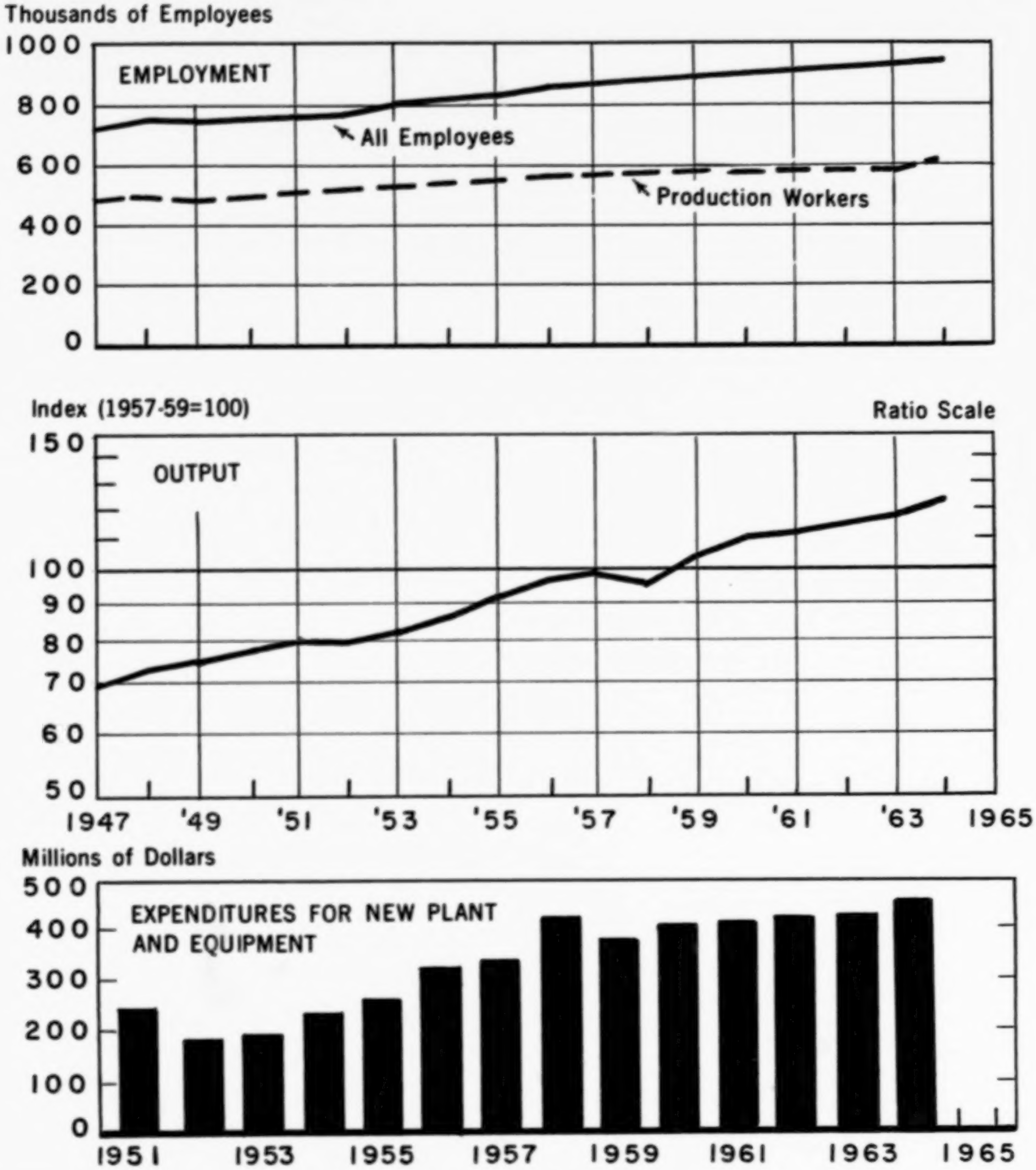
Additional economic advantages are being sought through the introduction of recent auxiliary technological developments. One newspaper, for example, has incorporated an optical reading device with its computer system in an attempt to increase output and eliminate manual re-keyboarding of tape prior to computer processing. Computer centers, connected by high-speed data transmission systems, are expected to grow in number and importance, particularly to service the smaller newspapers. These centers provide small printing plants that could not economically lease or purchase their own computers, with the opportunity to utilize and benefit from this technological advance.

Binding and finishing operations are becoming increasingly mechanized. Automatic multipurpose production machines, feeding mechanisms, and conveyors are being introduced more extensively to replace manual tasks and single function machines. Significant labor savings are also realized by the integration of machines and conveyors into a continuous flow system. The introduction of an automatic line for binding and related operations in one plant, for example, reduced employment in affected functions by 23 percent.

The trend to more extensive use of color is expected to continue. Electronic and other equipment has been developed for automatic color separation and is replacing more costly and less accurate manual techniques. These advances make process color methods more economical for many small printing shops. Some experts forecast that improved color processes will bring about more widespread use of color printing as an advertising medium. Facilities for full process color are available in more than 50 percent of daily and Sunday newspapers.

Operator prepares perforated paper tape used to actuate automatic phototypesetting equipment.

EMPLOYMENT, OUTPUT, AND CAPITAL EXPENDITURES IN PRINTING AND PUBLISHING



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board; expenditures, Bureau of the Census.

Faster printing presses and related equipment with centralized and automatic control are being introduced. New higher capacity presses at some newspaper plants are rated to operate at speeds twice as fast as those they replaced. On some modern presses, control consoles are designed so that virtually all running adjustments can be made by one man. Other trends include the introduction of the significantly faster web presses and more productive sheet-fed presses. Technological improvements in gravure printing equipment and platemaking techniques reportedly make this process more competitive with offset and letterpress methods, especially on longer runs. Forms of electrostatic printing have promise of greater speed and flexibility than conventional printing presses, and commercial applications are expected within a short time.

Research and development expenditures by the printing and publishing industry are very small, but are increasing. The major sources of future new developments in printing equipment, processes, and paper are expected to continue to be the result of research carried on by industry suppliers of equipment, film and chemicals, and the paper industry. Printing research companies and associations, however, are reportedly increasing their budgets. For example, the budget of the American Newspaper Publishers Association's Research Institute in 1965 was about triple the budget for 1958, and research employment was about double. In order to benefit fully from future new equipment and processes, some experts believe that even greater attention to research and development may be needed.

Plant and equipment expenditures are increasing. Annual outlays for new plant and equipment (Census data) have exceeded $400 million since 1960, and in 1964 reached $463 million—a record high for the printing and publishing industry. The outlook is for slowly rising expenditures for new plant and equipment over the next few years. According to one industry survey, the largest share of investment for 1965 will be for offset presses. Factors impeding faster growth of investment include the reluctance of some firms to replace old but serviceable equipment; and the practice of leasing rather than buying new equipment to avoid risk of obsolescence and to eliminate maintenance.

Manpower Trends and Adjustments

Employment is expected to increase. Total employment in printing and publishing (BLS data) was 950,500 in 1964, 870,000 in 1957, and 721,000 in 1947. Between 1957 and 1964, employment increased at an average annual rate of 1.3 percent, compared to 1.9 percent between 1947 and 1957. Although employment is likely to continue to increase, the growth rate is expected to continue to be significantly below the production growth rate, because of greater efficiency provided by technological change.

Production worker employment is growing at a slower rate than total employment. Between 1957 and 1964, the number of production workers increased at an average annual rate of 0.9 percent (from 563,700 to 601,400 workers), significantly below the 1.5 percent annual growth rate during 1947–57. The ratio of production workers to total employment fell steadily from 68 percent in 1947 to 63 percent in 1964, and may continue to decline. The outlook, however, is for continued moderate gains in production worker employment.

Occupations and job skills are changing. Advanced types of printing equipment, in many instances, tend to change the duties of machine operator to a monitor or tender, to eliminate manual production and materials-handling functions, and to create jobs requiring new skills.

	Average annual percent change
All employees	
1947–57	1.9
1957–64	1.3
Production workers	
1947–57	1.5
1957–64	.9
Output	
1947–57	3.6
1957–64	3.2

Tape-operated linecasting machines are displacing linotype operators but are creating new jobs that involve preparing paper tape and monitoring the linecasting machines during production. In some smaller newspapers, women typists are being trained to produce paper tape by manipulating the typewriter-like keyboards on teletypesetting tape perforators.

Plants mechanizing bindery processes are reducing hand and single-function machine operations. Hand stitchers and bookbinders are among occupations being replaced by new equipment. Some new jobs require monitoring multifunction equipment and automatic lines.

The outlook for skilled workers will remain favorable over the next decade. Occupations involving photographic skills will increase in importance as phototypesetting and other camera processes gain in application. In general, a knowledge of chemistry, physics, and electronics will become increasingly important.

Adjustments to the advent of computer-produced tapes for typesetting continue to be issues in labor-management negotiations. Under terms of one recent contract agreement involving several newspapers in a large metropolitan city, union approval is required prior to adoption of new types of automatic machinery and other technologies in composing rooms. This involves, particularly, computer-produced tapes, and tape which is transmitted to the newspaper by wire services. Moreover, a portion of the publisher's savings from tape supplied by wire services to automatically operated typesetting machines are to be paid into an automation fund which will be used to retrain printers, provide benefits for early retirement, and supplement existing welfare and pension funds.

Training programs to provide skills needed for modern printing technology are being expanded by unions, trade associations, and management. For example, a national training center established by the International Typographical Union (ITU) in the mid-1950's provides members from all over the country with an increasing number of tuition-free courses to keep abreast of changing technologies and skills. In addition, members trained at this school often serve as instructors in training programs carried on in their own local unions. Some major contracts provide eligible employees, whose jobs are eliminated, with retraining at company expense. Joint management-union committees have also been formed in some plants to oversee training. Another example of union-sponsored training is the long established school operated by the International Printing Pressmen and Assistants' Union of North America.

Labor-management negotiations are increasingly concerned with issues to increase job security and facilitate adjustment to new technologies. Of 37 key agreements in printing and publishing, 6 agreements in 1963 covering nearly 11,000 workers contain severance pay and layoff benefit plans. Several contracts provide for management to supply advance notice —sometimes in writing—90 days before a technological change is introduced. Joint union-management committees have been established under some agreements to resolve staffing, wage rates, and working conditions involving new equipment. In the newspaper industry, labor and management in early 1964 discussed undertaking joint factfinding studies of the past and potential impact of new technology on employment opportunities and means of avoiding jurisdictional disputes.

Selected References

Technological Developments

"New Production Technology," *Book Production Magazine*, December 1963, pp. 42a–48a.

"The Next Big Jump is Near in Printing," *Business Week*, Apr. 24, 1965, p. 92 ff.

"Optimism Prevails for 1965—As Printers and Lithographers Reveal Buying Plans," *Inland Printer/American Lithographer*, January 1965, pp. 34–36.

Perry, John H., Jr. "Perry, the Experimenter, Views Change in Printing," *Editor and Publisher*, June 13, 1964, p. 10.

Smith, Stanford. "Technological Developments in Newspaper Publishing," Statement Before the Antitrust Sub-Committee of the House Judiciary Committee, 88th Cong., 1st sess., Mar. 14, 1963, 24 pp.

Technological Change—Its Impact on Industry in Metropolitan Chicago—Printing and Publishing Industries. A Report by Corplan Associates of IIT Research Institute, 1964, 44 pp.

Winkler, J. Homer. "New Developments in the Printing Industry in the United States," *The American Pressman*, October 1963, pp. 6–7 ff.

Manpower Trends and Adjustments

Automation. Proceedings of the Printers' Workshop Union Forum, April 28–29, 1962, Sheraton-Palace Hotel, San Francisco, Calif. Sponsored by San Francisco Typographical Union, No. 21, 76 pp.

Goldstein, David H., M.D. and C. Raymond Hulsart. "Automation: A Clinical Study," *Journal of Occupational Medicine*, April 1964, pp. 169–173.

"Printers Prepare for Change," *Business Week*, Aug. 31, 1963, pp. 68–70.

Scheid, Kenneth G. "Graphic Arts Management—Are There Expensive Gaps?" *Book Production Magazine*, November 1963, pp. 69–71.

The Synthetic Materials and Plastics Products Industry (SIC 282, 3079)

Summary of Outlook Through 1970

Introduction of new and improved synthetic materials and products is expected to continue at a rapid pace. Processing innovations include larger, faster, more continuous equipment, new combinations of molding and forming techniques, and foamed-in-place and ultrasonic joining techniques. Although these and other advances, such as adaptations of materials for more efficient processing, reduce unit labor requirements, the rapid growth of output is expected to result in higher employment levels over the next 5 years. A number of companies offer retraining programs to meet the frequent changes in materials, products, and processing. Some collective bargaining agreements contain specific provisions to ease adjustment to technological change.

Outlook for Technology and Markets

Total production of synthetic materials (SIC 282) and plastics products (SIC 3079) is expected to continue its high rate of growth. Synthetic materials include plastics, resins, rubber, and manmade fibers except glass. Output increased at an average annual rate of 11.1 percent between 1947 and 1957 and 13.6 percent between 1957 and 1964, according to the Federal Reserve Board Index of Industrial Production (FRB index). A continuation of the 1957–64 growth rate is expected through 1970.

Output of plastics and synthetic resins (SIC 2821), the fastest growing segment of the industry, increased at an average annual rate of 17.8 percent between 1957 and 1964 (FRB) and is expected to continue to increase at a high rate.

Output of synthetic rubber materials (SIC 2822) is expected to maintain its postwar rate of growth of about 6 to 7 percent annually (FRB).

Manmade fibers production (SIC 2823, 2824), another fast-growing segment, increased at an average annual rate of 8.3 percent between 1947 and 1957 and 10.4 percent annually between 1957 and 1964 (FRB). Output of manmade fibers for 1970 is estimated, by an industry source, as possibly more than 4.5 billion pounds, which would mean an average annual rate of gain from 1964 of 8.3 percent.

Plastics products (SIC 3079) include films, sheets, rods, and miscellaneous items. Output has been increasing at a very high rate between 1957 and 1964, and probably will continue to increase at an average annual rate of greater than 10 percent.

Plastics markets are expanding. Building construction, packaging, electronics, agriculture, and automobile manufacture are major industrial markets with aerospace and defense industries increasing in importance. Appliance, housewares, and toys are major consumer markets. Toughness, insulating properties, light weight, resistance to chemicals, and ease of fabrication make plastics competitive with metals, glass, wood, and other materials.

In construction, with a 1964 consumption of 2.3 billion pounds, plastics are used increasingly in wall boards and gutters and for glazing (as a glass substitute). Use of plastics in construction is expected by trade sources to increase substantially by 1970.

Plastics pipe is being used increasingly for residential plumbing, gas distribution, process, and drainage purposes. Over 27,000 miles of plastic pipe have been installed in the past 10 years. Excellent performance in rural areas induced the Farmers Home Administration to finance more than 10,000 miles since 1960. Sales of plastic pipe are expected by the Plastics Pipe Institute to triple by 1970.

Plastics use for container packaging of milk and produce has been expanding at a rate of more than 20 percent annually.

Plastics consumption per automobile has increased steadily from an average of 21 pounds in 1960 to an estimated 35 pounds for 1965; it is expected by industry sources to reach 45 to 50 pounds by 1970.

The aerospace industry, drawing on a wide range of plastics to meet its requirements for lightweight structural materials, thermal insulation, sealants and other specialized needs, consumes almost 15 million pounds annually. Demand by this industry for plastics is expected to more than triple by 1970.

Continued improvements in engineering plastics (acetals, ABS, rigid vinyl and others) are bringing additional uses in building structures, boats, automotive bodies, chemical plant equipment, appliance housing, and in competition with exotic metals for specialized aerospace applications. The output of foamed cellular plastics—about 300 million pounds in 1964—used extensively in appliances, is expected to double by 1970.

Plastics materials are being modified to obtain specific properties. Synthetic materials are produced by blending and "cooking" the intermediate synthetic materials derived from the processing of natural gas, petroleum, other hydrocarbons, air, water, salt and limestone. For instance, ethylene gas, when subjected to extreme heat and pressure, becomes a solid substance—PE resin, which can then be molded, extruded, calendered, laminated, woven, or otherwise shaped into synthetic products. Resins, plastics, synthetic rubber, and synthetic fibers differ more in terms of external characteristics of the final product and method of manufacture than in basic ingredients.

By polymer or molecular engineering, older-type resins are being improved and new resins such as the commercially successful polypropylene are being produced. Polystyrenes are now relatively light and heat stable, chemically resistant, and have greater flexibility. One new material, ionomers, has a melt strength which makes possible very thin coatings (up to 0.2 of a mil). In one new application—power cable insulation—ionomer resins show corona (electrical) resistance 100 times greater than typical electric grade PE resin.

Another new plastic can conduct electricity and can be applied as a liquid to produce a conductive surface on a common insulator, and, if desired, a printed circuit. Some progress has been made in developing plastics that maintain dimensional stability at a wide range of temperatures. Some plastics are tailored to give more efficient processing, such as new resins which make possible faster curing.

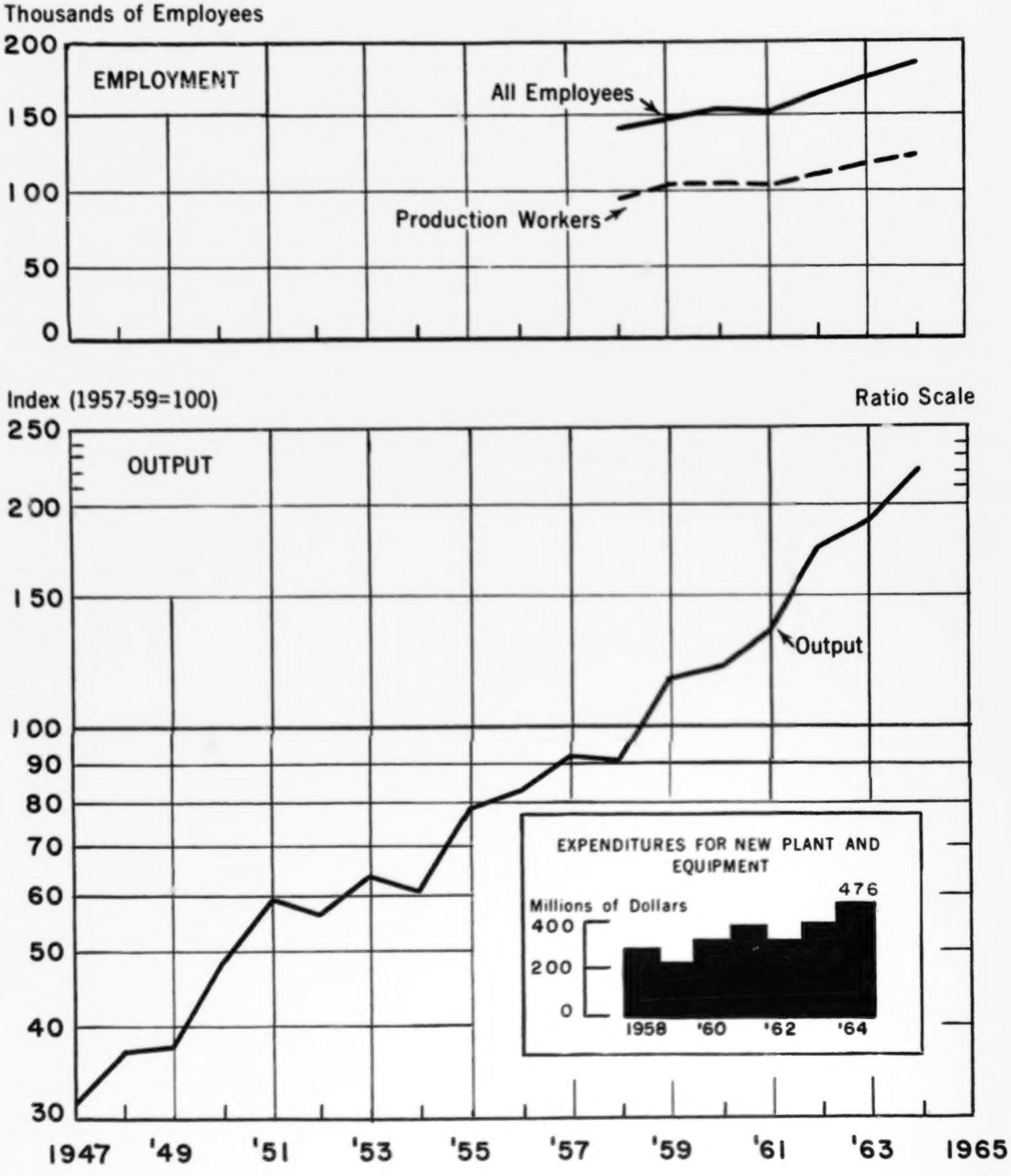
Polymers are often combined with other materials to produce desirable composites. Rubber blends (copolymers) have low-temperature flexibility, improved impact strength, and can be fabricated into many parts at a fraction of the cost of rubber parts for the same use. A combination of plastics and metal such as polypropylene core and aluminum provides high strength, low cost, ease of production, machinability, weldability, stability, and sound and vibration damping. Plastics wood composites via atomic radiation promise new markets for plastics in furniture construction.

Plastics also are being combined with other plastics to produce superior products such as new leather-like materials composed of a urethane polymer base reinforced with polyester. Such materials, now used in footwear, may have great potential application in a number of industrial uses.

Larger, faster, more continuous and more complex equipment is being used in plastics processing. Sheet forming with simultaneous three-level printing, automatic forming procedures, and high-speed plastics welders with automatic feed have been developed. New machines and mold designs, applied to compression, injection and blow molding, are making possible fully automatic transfer molding techniques. A new parts stacker makes molding a continuous automatic operation from the stock material through forming, cutting, and stacking the finished product. These machines and equipment are making possible considerable labor savings

Operators oversee computer console which monitors chemical plant conditions and types out operating log sheets.

EMPLOYMENT, OUTPUT, AND CAPITAL EXPENDITURES IN THE SYNTHETIC MATERIALS INDUSTRY



Sources: Employment, Bureau of Labor Statistics; output, Federal Reserve Board; expenditures, Bureau of the Census.

through more efficient materials handling and faster processing.

A new system for producing phenolics, operated from a central control panel by punched cards, combines a central blending system, mixing and automatic weigh-feeding unit to give a better quality product and reduction in holding time. Very recently, a continuous process for making acrylic sheet has been developed in place of the traditional complicated batch process, reducing costs considerably.

Fabricating methods are being combined for faster production and better mixing of materials. For example, extrusion injection combines use of the extruder screw with injection molding, enabling the colorant to be mixed in the molding process. Injection and compression molding are combined in a form of transfer molding in which plastics material is melted and transferred to the cavity for shaping. Development work is underway to combine thermoforming and blow molding into a single machine operation to produce hollow objects, and to combine injection molding and thermoforming operations to produce cup-shaped objects. In each case, conventional competing techniques are joined into one piece of equipment to do a more efficient job than either can do separately, with resulting economies in labor and materials.

Newly designed, larger equipment is being used to perform operations hitherto considered not feasible, such as injection molding of very large integrated plastics components of automobiles (instrument clusters, grilles, body and fender panels). Large multicavity machines are being developed to make, simultaneously, such matching pairs of parts as fenders. Rotational molding of powdered resin is being adapted to produce large and complicated shapes as appliances, housewares, and furniture at much less cost than other methods. Screw injection, introduced in 1961, provides improved moldings from a wider range of plastics materials and is replacing other types of injection molding equipment.

Some new processes are based on properties of resins and plastics rather than on machine development. Foamed-in-place techniques have advanced the application of various plastics, especially polyurethane. Flexible polyurethane foams can be cast directly to shape in molds. In the frothing method, the foam is pre-expanded prior to molding (rather than pouring liquid ingredients and allowing them to rise into a foam), offering the advantage of lower overall foam density and lower pressure buildup. Recent progress in use of ultrasonics makes possible the joining of rigid plastic parts at areas remote from where the ultrasonic sealing tool is applied. Ultrasonic vibration waves are transmitted through the structure, thereby reducing labor and assembly fixture costs.

Other new plastics process techniques are expansion molding, using the pressure of expanding propellant rather than external pressure; production of foam film by extrusion for further fabrication; and a fluidized-bed process for coating metals.

Newly formulated synthetic rubbers are increasing in importance. The advantageous properties of some of the recently developed synthetic rubbers are resulting in their increasing industrial use as adhesives, insulated wire, belting, hose, rolls and tubing, and increasing consumer use as flooring, footwear, household goods, toys, and in tire accessories and repair materials. As a proportion of total new rubber consumption (excluding reclaimed rubber), synthetic rubber has risen from 51.3 percent to 75.1 percent between 1954 and 1964. SBR (styrene-butadiene rubber) continues to be the predominant synthetic rubber, accounting for about 70 percent of total synthetic consumption in 1965.

The stereo, or stereoscopic, rubbers (polybutadiene, polyisoprene, and ethylene-propylene terpolymer) are estimated to be about 13 percent of total synthetic rubber consumption in 1965 and may be as much as 28 percent in 1975 compared to 54 percent for SBR. The new stereos (in the pilot plant stage in 1960) have already started to replace SBR in some applications. For example, PBR (polybutadiene rubber) is increasingly used in tire production; and EPT (ethylene-propylene terpolymer), introduced in 1964, is believed to have a potentially large market because of resilience and rebound nearly equal to natural rubber, and better chemical and aging properties. EPT's excellent insulating properties make it particularly attractive to the wire and cable industry.

Intensive research and development have resulted in a synthetic equivalent of natural rubber (cis-1,4-polyisopyrene) which is now in commercial production. Processing techniques are less complicated than for natural rubber, and greater product uniformity is obtained because of precise quality-controlled chemical processes.

Faster new techniques and equipment, many from plastics manufacturing, are being used in synthetic rubber processing. The introduction of new molding techniques has cut labor requirements, reduced scrap, and decreased the proportion of rejects. Injection molding machines of the automatic transfer type make possible fast curing and accurate heat control. Machines providing continuous mixing or warm-up, with resulting reductions in capital and labor requirements, are beginning to be used. Major advances in calendering are being used by rubber manufacturers, with resulting improved accuracy and lower cost output. A new technique in stock preparation using synthetic materials premixed with carbon has decreased processing time for synthetic rubber production.

New manmade fibers are being developed and established fibers given new properties. Special properties and end-uses for manmade fibers are brought about by chemical modification and coatings, or by chemical finishes, for durability, strength, and dyeability. Manmade fibers offer such advantageous properties as improved thermal insulation, control of luster, resistance to wrinkling, and "stretchability." The market for polyester has been improved by the use of polyester in "durable press" (no ironing) apparel fabrics. Space technology is making use of synthetics because of packageability, ease of handling, and light weight; balloons for deceleration and reentry vehicles are an example. Synthetic fibers are being used with rubber and plastics to improve the strength and resistance of conveyor belts to temperature changes. Specialty fibers and filaments have been developed for industrial uses, e.g., low-adhesion, plastic-coated glass fibers, and acrylic fiber for cryogenic applications. New rayon fibers (high wet modulus) are expected to improve their competitive position relative to noncellulosics.

Process control computers are being more widely used. First introduced in 1960, there were about 30 digital-process control computers (including several closed-loop systems) installed or being installed for the production of plastics and other synthetic materials as of mid-1964. At least four of these computers were used in the production of synthetic rubber and the blending of rubber compounds. Five computers were used for process control studies or in a pilot operation.

Capital expenditures are increasing. Expenditures on new plant and equipment for synthetic materials (SIC 282) reached $476 million in 1964, up from $291.2 million in 1958. Capital expenditures by the plastics products industry (SIC 3079) has been steadily increasing from $77.2 million in 1958 to $182.6 million in 1964. Rising levels of demand, especially for polyethylene (PE), polyvinylchloride (PVC), polystyrene, phenolics, and epoxies, are stimulating plant expansions.

Research and development activities are extensive. Funds for R&D in the chemical industry amounted to $1.3 billion in 1963 (National Science Foundation) and are expected to rise substantially over the next 5 years. Trade sources estimate that about 25 percent of the chemical research funds are spent in plastics science. Industrial research on polymer manufacturing processes and attempts to improve properties of polymer, for example through radiation, are being increased. Emphasis is being placed on stronger resins as well as interphase properties, which are weak points in composite structures.

In synthetic rubber research, stereo rubbers are stressed. The effort to produce a butadiene or isoprene polymer of the most desirable characteristics in terms of green strength, tack, processability, tensile strength, and dynamic properties continues to be a major subject of research. Other research is directed to the mechanism of the action of chemicals as accelerators, antioxidants, and antiozonants for synthetic rubbers.

Manmade fibers research is emphasizing improvement of existing fibers for special properties and uses rather than the development of totally new fibers. The U.S. Air Force is undertaking research into forming useful new fibers from nonmetallic materials possessing high strength, high elastic modulus, and superior high temperature performance properties for use in aerospace systems.

Manpower Trends and Outlook

Output per man-hour in the manmade fiber industry has been rising moderately. Productivity indexes are available only for manmade fibers. Between 1957–63, output per all employee manhour increased at an average annual rate of 3.5 percent and output per production worker manhour increased at 3.9 percent (compound interest computation).

Employment is expected to increase. Total employment for the synthetic materials industry (SIC 282) amounted to 143,000 in 1958, rose at an average annual rate of 4.2 percent to 183,100 in 1964 or a total of 28 percent, and is expected to continue to increase into the 1970's. During the 1958–64 period, employment increased 21 percent in plastics, 39 percent in synthetic fibers, and 33 percent in synthetic rubbers.

In the plastics products industry (SIC 3079), employment increased from 101,200 in 1958 to 170,900 in 1964, a total of 69 percent, or at an average annual rate of 9.1 percent. Employment in plastics products is expected to continue rising at rates higher than those for synthetic materials.

SYNTHETIC MATERIALS

Average annual percent change	
All employees	
1958–64	4.2
Production workers	
1958–64	4.1
Output	
1947–57	11.1
1957–64	13.6

Proportion of production workers has remained virtually the same since 1958. For the period 1958 to 1964, the proportion of production workers to total employment in the synthetic materials industry changed only slightly, from 67.6 percent to 67.2 percent This stability in the production-worker to all-employee ratio was common to all the synthetic materials subcategories. The high proportion of nonproduction workers reflects the great number of research personnel. In the plastics products industry, however, production workers were 79 percent of all employees, the same ratio as in 1958.

More complex instrumentation, equipment, and operations are requiring higher skill levels. For example, skills needed by operators are getting closer to those of technicians. There is a continuing need to train laboratory aides and technicians to perform tests, procedures, and other tasks so that research scientists and engineering staff personnel may devote their energies to more important scientific work and for coordination of all aspects of a project. In recognition of the need for chemical and instrument technicians in research and production, the U.S. Office of Education has prepared 2-year post-high school curricula.

A number of companies have retraining programs. These companies provide extensive retraining in classroom, laboratory, or on the job. One company conducted comprehensive retraining for operations in a new plant replacing an obsolescent plant, thereby holding to a minimum the number of workers who were laid off or retired. At another company, under a collective bargaining agreement, workers displaced to lower paying jobs by technological change retain their previous pay rates for 185 days, and workers whose jobs are eliminated are given retraining and 3 months' work in a labor pool. At one company, reimbursement for schooling for any chosen trade or occupation is provided for those to be terminated.

Some contracts contain provisions concerning procedures to be followed in event of technological displacements. Among the contract measures included are provisions for early warning; discussion and consultation; agreement between union and management on the date and time period of introduction of automatic processes; careful scheduling of the change during the various stages of introduction; retention of displaced employees where possible on the basis of skill, without regard to seniority; and transfers and benefits for displaced employees, based on seniority.

Selected References

"A Technological Review of the Rubber Industry," *Rubber Age,* December 1964, pp. 389–396.

Burton, W. H. "New Materials in the Chemical Industry," *Industrial Research,* November 1964, pp. 50–58.

Chemical Technology, A Suggested 2-year Post High School Curriculum, U.S. Department of Health, Education, and Welfare, 1964.

D'lanni, J. D. "Metamorphosis in Rubber," *Industrial Research,* February 1964, pp. 55–63.

Dubois, J. H. "The Sophisticated Plastics—How They Will Affect Industry," *Plastics World,* May 1965, pp. 30–33.

Indexes of Output per Man-Hour, Man-made Fibers Industry, 1957–1963 (BLS, October 1965).

"New Chemicals and Materials," *Industrial Research,* September 1965, pp. 74 ff.

"Plastics Engineering," *Modern Plastics,* March 1964, pp. 111–118.

"Plastics 1964: Soaring Growth, Dynamic Complexity, New Directions," *Modern Plastics,* January 1965, pp. 76 ff.

Popper, H. "CPI Manpower," *Chemical Engineering* October 12, 1964, pp. 189–204.

Wage Chronology: American Viscose (BLS Report 277, September 1964).

Workman, R. E. "The Rubber Industry, A Ten-Year Forecast," *Rubber Age,* August 1965, pp. 49–54.

The Petroleum Refining Industry (SIC 291)

Summary of Outlook Through 1970

Increases in output per man-hour are expected as expenditures for new plant and equipment and for research and development increase. Computer control, improved instrumentation, and new processing techniques are being adopted to obtain operating economies and product quality improvements, especially by the larger producing units in the industry.

Lower employment levels are expected, especially for production workers, continuing the declines which began in the 1950's. Reductions in unit labor requirements are not expected to be offset by anticipated increases in total output. Employment decline in older plants, however, may be partly offset by an increase in jobs in the growing petrochemical sector of the industry. Technological changes often require extensive retraining of production workers, as well as additional training for technical workers. Measures providing early retirement and severance pay have been adopted.

Outlook for Technology and Markets

Production is expected to continue to rise slowly. Through 1970, output is expected to increase. Output grew at a rate of about 2 percent annually during 1957–63. This was substantially lower than the average annual rate of 5 percent during 1947–57, when railroad dieselization, farm mechanization, substitution of oil and gas for coal in home heating, and expanding automobile and aviation markets were sources of increased demand. According to projections of the output of petroleum products prepared by *Resources for the Future, Inc.,* the annual rate of growth from 1960 to 1970 may range between 1.5 and 3.9 percent. According to U.S. Bureau of Mines estimates, total U.S. consumption of petroleum products rose about 3.4 percent yearly between 1953 and 1963 and is expected to rise at about the same rate through 1970.

The production of petrochemicals is expected to increase substantially. Growing demand for synthetic materials is resulting in the diversion of more crude oil to lighter hydrocarbons, which, along with natural gas and gas liquids, form the basis for petrochemical production. The total output of petrochemicals rose at an average annual rate of about 10 percent, from 18 billion pounds in 1956 to 35 billion pounds in 1963, and is expected, according to projections by *Resources for the Future, Inc.,* to continue to rise from 6 to 11 percent yearly through 1970, to as much as 71 billion pounds.

New refinery processes are concentrated on improving product quality, raw material utilization, and efficiency of operation. Advances in processing, utilizing longer lasting and more stable catalysts, and more nearly optimized operation through closer control, result in significant increases in output of the most valuable products, such as higher grade liquid products, from each barrel of crude petroleum. Recent developments in the hydrocracking process result in upgrading heavy bottom oils to yield substantially more higher value gasoline and distillate products. Hydrocracking capacity, introduced in 1960 is expected, according to estimates made by the *Oil and Gas Journal,* to grow 900 percent through 1970, replacing as much as 10 percent of the industry's catalytic cracking capacity. The Bureau of Mines estimates that extension of these facilities could ultimately result in significant reductions in crude oil requirements.

Computers are being used increasingly for process control. According to annual surveys by the *Oil and Gas Journal,* about 100 digital control computers were in operation or planned at the end of 1964, compared with about 60 at the end of 1963. Of the 1964 total, 35 were for petroleum refining compared with 25 a year earlier, and 65 in petrochemical processing compared with 35 in 1963. The industry began using process control computers in 1959, with most of the installations made since 1962. This development follows the increasing use of instrumentation, which accounts for the high degree of automatic operation characteristic of oil refineries.

Computers are being introduced to correlate large volumes of data about processing variables such as temperature, flow, and pressure. In conventional plants, instruments sense, measure, and record data, and operators manually make the calculations and value adjustments necessary for controlling processing. Most of the computers now in use receive data in the form of instrument signals, perform calculations, and turn out operating instructions, but the operator still makes the indicated adjustments. A few more advanced installations feature closed-loop or unattended control, the computer giving signals that activate mechanisms to position control valves, but complete refinery control by computer is not yet considered entirely satisfactory.

Direct benefits of computer process control include increased production, reduced operating costs, and improved quality control. In some cases, the savings have been found to amount to $100,000 to $500,000 annually per installation. Better technical and operating data, reduced inventory requirements, and improved plant safety have provided additional though intangible savings. To a certain extent, computers permit complex calculations that would otherwise not be made because of high cost. Since the net result is more output with about the same work force, productivity is increased.

By 1975, close to half of all refineries will probably have some degree of computer process control. The rate of adoption may be retarded by the need to train technicians, the need for more accurate and reliable instrumentation, and problems in adapting certain types of processes to computerization. The most successful applications are expected in new plants. The rate of introduction, therefore, may be quickened over the next few years with the expected increase in construction of new and larger plants.

The use of radioisotopes is increasing. Radioisotopes are being used increasingly in gaging and research to improve accuracy of measurement and quality control. Radiography, using radioisotopes, permits on-stream inspection of refining units, increasing operating reliability. Radioisotope tracing techniques and radiation are also being applied to the development of improved catalysts and are being introduced as a more efficient and less complicated means of processing petrochemicals.

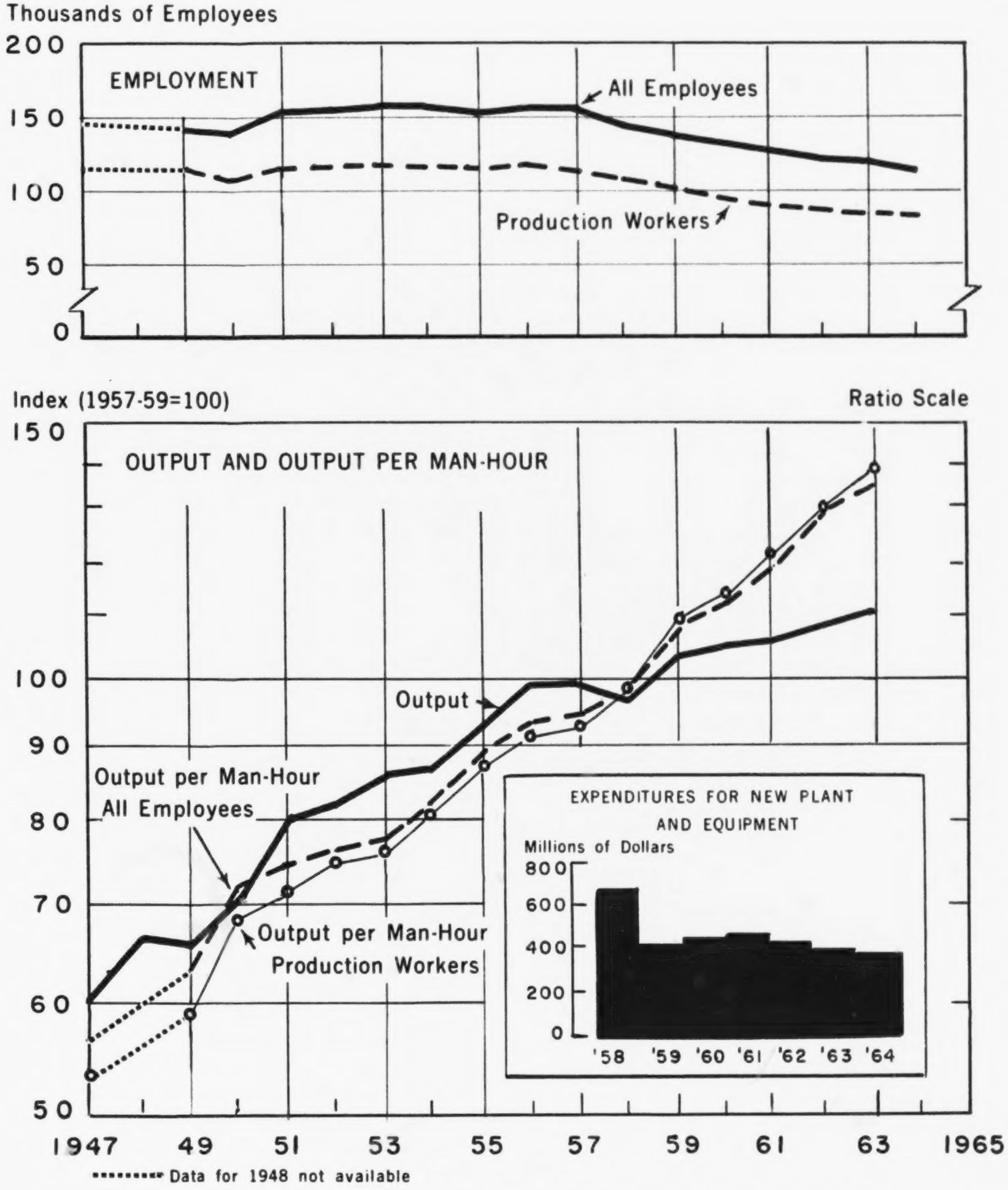
Research and development activities are increasing. Expenditures for R&D by petroleum companies, according to the National Science Foundation, amounted to $182 million in 1956 and rose to $315 million in 1963. According to McGraw-Hill, R&D expenditures planned by the industry are expected to increase about 70 percent by 1974. The industry's R&D expenditures as a percent of net sales rose from 0.8 percent in 1957 to 1 percent in 1961—a relatively high ratio for a nondefense industry. The number of R&D scientists and engineers rose from 6,900 to 9,000 in 1956–63.

Changes in demand have led to increased spending on R&D related to product development. Chemical research by the petroleum industry, according to U.S. Department of the Interior estimates, rose from $51 million in 1957 to $72 million in 1964. According to industry sources, there is a promising future demand for petroleum-derived synthetic organic chemicals, food supplements and nutrients, as well as agricultural chemicals, including fertilizer manufacture.

Investment in new plant and equipment is increasing sharply. Expenditures for new plant and equipment rose from $316 million in 1947 to a peak of around $877 million in 1957, and declined to about $384 million in 1964. However, expenditures are expected to rise more than 100 percent in 1965 over 1964, both for refining and for petrochemical plant and equipment. Over 80 percent of the industry's capital spending through 1967 will be for replacement and modernization, according to estimates by McGraw-Hill.

Refineries are becoming increasingly larger, more compact and complex. Between 1947 and 1963, the number of operating refineries decreased from 361 to 282. The average size of operating refineries increased by 144 percent, from 14,700 barrels a day throughput capacity to 35,700 barrels a day. As old plants are shut down and new, larger plants built, these trends will continue.

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN PETROLEUM REFINING



Sources: Employment and expenditures, Bureau of the Census; output and output per man-hour, Bureau of Labor Statistics.

Substantial economies are achieved by increasing plant size. For example, the consolidation of three catalytic cracking units at one refinery, each with a capacity of 30,000 barrels a day, into one unit of 90,000 barrels a day resulted in an increase of three times the capacity per employee. One factor in the building of larger refineries is the availability of more durable components and corrosive-resistant metals which reduce the frequency of costly shutdowns.

Manpower Trends and Adjustments

Output per man-hour will probably continue to increase at the industry's high postwar rate of growth—5 to 6 percent a year. Output per all-employee man-hour rose at an average annual rate of 6.6 percent from 1957–63, compared with 5 percent during 1947–57. Output per production worker man-hour increased at a faster rate, 7 percent yearly from 1957 to 1963, compared with an average annual rate of 5.7 percent in 1947–57.

Employment is expected to continue the decline which began in the 1950's, but probably at a slower rate. Total employment, according to the Bureau of the Census, which amounted to 145,800 in 1947 rose to 153,900 in 1957, and then declined to 113,900 in 1964. Production worker employment declined slightly from 113,800 in 1947 to 112,500 in 1957, but registered a considerable decline to 81,700 in 1964. Opportunities may be enlarged in the petrochemical sector of the industry, particularly in the Gulf States. At the same time, labor may be displaced at older, obsolete plants or units which become too costly to operate.

While total employment is expected to continue its decline, production worker jobs are expected to decline more rapidly. Production worker employment as a percent of total employment fell from 78 percent in 1947 to 72 percent in 1964. Between 1950 and 1960, the number of mechanics, repairmen, pipefitters, and foremen increased, while the number of employees in service, semiskilled, and laborer occupations declined substantially. Skilled craftsmen in maintenance work may be increasingly affected by the use of computers in engineering, automatic welding, and new construction techniques.

	Average annual percent change
All employees	
1947–57	0.5
1957–64	–4.2
Production workers	
1947–57	– .1
1957–64	–4.5
Output	
1947–57	5.0
1957–63	2.0
Output per all-employee man-hour	
1947–57	5.0
1957–63	6.6
Output per production worker man-hour	
1947–57	5.7
1957–63	7.0

Nature of operator's job is undergoing change. In older plants, operators work mainly out of doors, adjusting valves and taking readings. In modernized units, operators monitor instruments displayed on control panels in office-like rooms and make adjustments by pushing buttons or levers. With integration of refinery units and greater centralization, operators in modernized plants often are required to have some knowledge of processes in other parts of the plant in addition to those in their own unit. With computer control, the operator may need to do less recording and calculating, although he continues to have responsibility for detecting or anticipating difficulty and making corrections as quickly as possible. Employers in modernized plants often require new employees to be high school graduates and to have some aptitude in mathematics and science.

Unions seek limitations on subcontracting of maintenance work. Some companies believe that maintenance work for the more complex new equipment can be performed more skillfully by outside specialists than by refinery employees. Also, with the increasing size and reliability and improved metallurgy, it becomes possible to reduce frequency of shutdowns for maintenance. Refinery turn-arounds (periodic general repair, inspection and cleaning of about 2 to 4 weeks' duration) that formerly occurred about once a year now are necessary only every 2 to 3 years. Technical advances have created a need for a skilled, well-trained regular maintenance force that makes up a large proportion of refinery employment.

Unions have responded by pressure for clauses in collective bargaining agreements that would limit, in various ways, the use of subcontracting. Of 23 major collective bargaining agreements (covering 1,000 or more workers) in 1959, in the petroleum and related products industry, 12 contained provisions limiting use of subcontracting. By 1965, of 21 major contracts, 14 had subcontracting provisions. The issue of subcontracting in this industry has from time to time generated jurisdictional problems between industrial and building trades unions.

Retraining programs are increasingly important. Employees on the job are generally retrained for new technology. Training for process integration which requires greater knowledge of the overall refining process and of instrumentation, in some cases, involves extensive classroom and on-the-job retraining. In one plant undergoing modernization, training for supervisors was conducted 6 months before startup, and for operators and helpers, 3 months before. Another company was able to retrain its employees in a 6-week program.

Severance pay plans are receiving more attention. Of 18 major collective bargaining agreements studied in the petroleum refining and related industries, 6 (with nearly half of employment covered by the study) had in 1963 severance pay and layoff benefit plans. A 1957 study of agreements in effect in 1955 and the first half of 1956 showed that only 2 out of 27 major contracts contained severance pay plans. For eligible workers, these plans provide cash benefits generally based on length of service.

Special early retirement programs have been worked out in some cases. Under special short-term provisions, workers at some modernized refineries have been encouraged to retire early by being paid larger allowances than the actuarial equivalent of normal benefits under regular retirement programs. This stimulus to attrition is intended to reduce the impact of employment reduction on younger employees.

Selected References

Technological Developments

An Appraisal of the Petroleum Industry of the United States, U.S. Department of the Interior, January 1965.

"Computer Control in the Oil Industry," *The Oil and Gas Journal,* Oct. 26, 1964, pp. 89–119.

"Computer Control Makes Solid Gains in Processing," *The Oil and Gas Journal,* October 1962, pp. 84–101.

Lawrence, C. J. "Signal Jumps Gasoline Yield to 90 Percent at Bakersfield," *The Oil and Gas Journal,* June 17, 1963, pp. 46–48.

Lawrence, J. H., Manowitz, B., and Loeb, B. S. *Radioisotopes and Radiation,* McGraw-Hill, New York, 1964.

McKenna, G. E., Owen, C. H., and Hettick, G. R. "Heavy Oil Catalytic Cracking Key to Refinery Modernization," *The Oil and Gas Journal* May 18, 1964, pp. 106–107.

Proceedings of the 29th Mid-Year Meeting of the American Petroleum Institute's Division of Refining, St. Louis, Mo., May 11–13, 1964.

Selected References—Continued

Manpower Trends and Adjustments

A Case Study of a Modernized Petroleum Refinery (BLS Report 120, 1956).

Collective Bargaining Clauses: Dismissal Pay (BLS Bulletin 1216, 1957), p. 2.

Industrial Retraining Programs for Technological Change (BLS Bulletin 1368, 1963), pp. 7–12.

Petroleum and Gas Industries Manpower Requirements, 1962, Washington, D.C., National Petroleum Council, 1963.

Recent Collective Bargaining and Technological Change (BLS Report 266, 1964), pp. 13–14.

Subcontracting Clauses in Major Collective Bargaining Agreements (BLS Bulletin 1304, 1961).

The Tires and Inner Tubes Industry (SIC 301)

Summary of Outlook Through 1970

Production is expected to continue to rise to new highs through 1970; the level of output will depend largely on motor vehicle production. Anticipated large outlays for new plant and equipment and continuing technological changes will increase output per man-hour, probably at the 1957–63 rate. Major technological advances being introduced include more mechanized and automatic materials-handling techniques; faster, larger capacity machinery; more extensive instrumentation and centralized machine control; and process integration.

Future employment levels probably will remain fairly stable; increases in output per man-hour enabling the industry to produce the increased output with about the same level of employment. Job requirements are expected to continue to emphasize a shift from manual skills to machine tending and console monitoring.

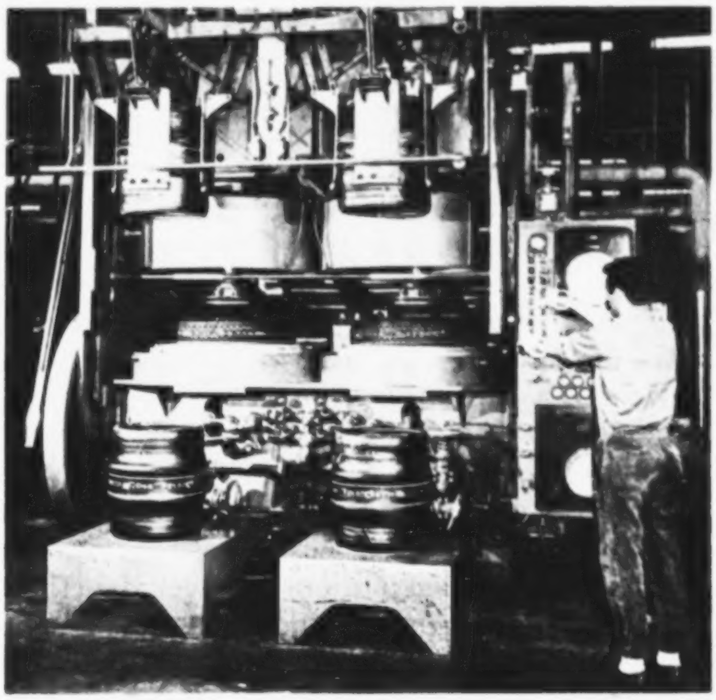
Outlook for Technology and Markets

Output will continue to reach higher levels. Tire and tube production (BLS index) rose at an annual rate of 4.1 percent from 1957 to 1963, substantially exceeding the rate of growth of 1 percent from 1947 to 1957. Tire and tube production in the next 5 years will probably grow at rates faster than in the recent past, but the levels of output will depend to a large degree on the growth rate of motor vehicle production.

Synthetic rubber will continue to take a larger share of the automobile tire market. In comparison to natural rubber, synthetic rubber eliminates several preparatory manufacturing operations, reducing unit labor requirements. Masticating, for example, a mechanical process which conditions the rubber, is unnecessary for synthetic rubber, since it arrives ready for Banbury processing. Man-hours can also be reduced by shifting the black-masterbatching process from the tire plant to the chemical plant where the synthetic rubber is produced.

In 1947, synthetic rubber accounted for 47 percent of all new rubber consumed for tires and related products; by 1964, it accounted for 74 percent. The outlook, according to *Resources for the Future, Inc.*, is for a continuing rise to as high as 77 percent by 1970. Although expanded research on natural rubber may improve its competitive position, synthetic rubber will continue to be favored over natural rubber because of its greater reliability of supply, consistent quality, higher curing temperature tolerance, and the ability to meet a variety of desired technical specifications. However, natural rubber, because of its relatively greater resistance to heat build-up and the inadequate supply of some synthetics, is likely to remain the major material for large truck and off-the-road vehicle tires.

New synthetic rubbers may improve tire performance and reduce material costs. Styrene-butadiene (SBR), which accounts for about four-fifths of synthetic tire rubber consumption, is expected to be displaced significantly over the next several years by a new family of polymers, the stereospecifics. This group, which includes polybutadiene, polyisoprene, and ethylene-propylene, represented only about a



Machine operator controls automatic curing presses used for vulcanization of tires.

seventh of synthetic tire rubber in 1964; the outlook is for a rise to more than a third by 1975.

Greater resistance to heat build-up, abrasion, and atmospheric deterioration are outstanding characteristics of these new synthetics as compared to SBR. Also, in the long run, some may offer considerable cost reductions as a result of their potentially lower price.

Improved cord materials may result in better tire quality. Nylon accounted for 49 percent and rayon for 45 percent of total tire cord material in 1964. Rayon's dominant position was reversed for the first time in 1963, culminating nylon's continuous inroads over the past 10 years. While almost all original equipment tires are made of rayon cord, about three-quarters of the replacement tire market—twice the size of the original tire market and still growing—utilizes nylon. Car manufacturers have resisted nylon not only because of the higher price, but also because, after standing for some time, nylon tires tend to become slightly flat. Intensive research is now underway to improve both rayon and nylon properties.

Recent introduction of new methods of tire construction, requiring more strength and rigidity in cords, may result in the use of new materials, such as fiberglass and wire. Polyester, now accounting for only 3 percent of cord production, also may become increasingly important in the next 5 years.

Use of radial ply tires may gain considerable momentum by 1970. Commonly used in Europe for trucks and automobiles, radial ply tires (plies placed straight across the width of a tire instead of the conventional criss-cross placement) have been available for several years in the United States, for trucks and off-the-road vehicles only. They are expected to be available for selected passenger cars in 1966. Industry experts forecast that from 10 to 20 percent of original equipment tires will be radial ply by 1970.

Compared to conventionl ply construction, flexing of the tread is considerably reduced in radial ply tires, resulting in lower heat build-up and less tread wear. However, this type of tire results in a relatively harder ride, and may initially meet consumer resistance. Developments in tire cord material and auto suspension may alleviate this disadvantage. Radial ply tires are more expensive to manufacture because of additional production equipment and increased unit man-hour requirements. New types of equipment, however, are being developed to simplify the production process and reduce costs.

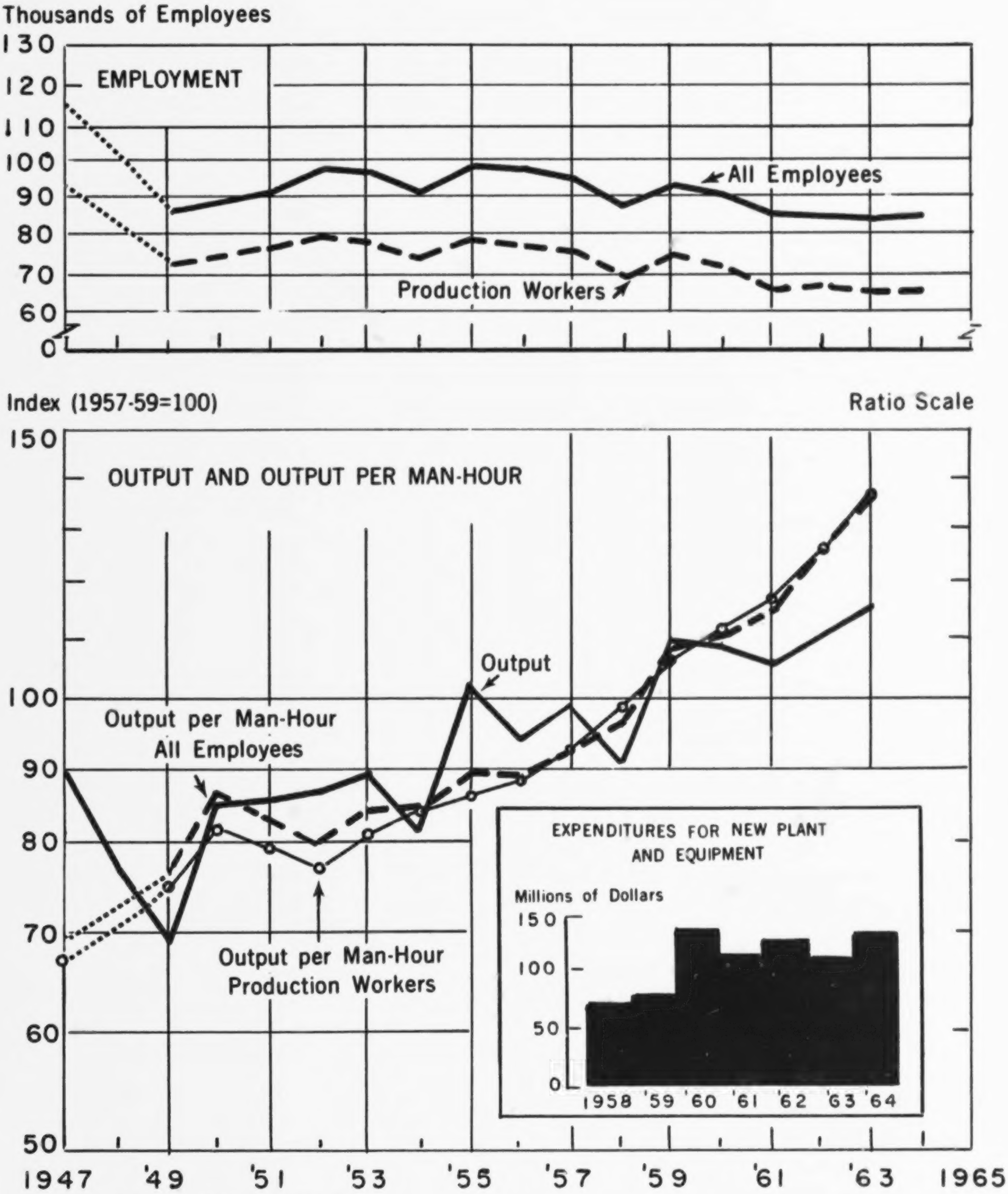
Continuing trend toward fewer ply tires is expected. The two-ply tire, marketed for the first time in 1961, as a result of the development of new high strength cord materials, has already replaced the four-ply tire as standard on more than 95 percent of new automobiles and is beginning to make inroads into the replacement tire market. The present 10-ply truck tire—which was reduced from 12-ply—is expected to be further decreased to 4-ply in the near future. Experts claim that tires with fewer, stronger plies build up less heat with no less strength than tires with more plies. Because fewer plies are processed, production costs and unit man-hour requirements are somewhat lower.

Recent changes in tire design may affect unit man-hour requirements. New product developments, such as tread studs for better traction and rounded shoulders for safer cornering, have recently been marketed with prospects of gaining wide acceptance. Also, passenger-car snow tires, while not new, have almost tripled in output from 1957 to 1964.

Some designs requiring more labor per unit than conventional tires are increasing in importance. For example, production of white sidewall tires, which almost doubled from 1957 to 1964, requires about 20 percent more man-hours per tire. In 1964, white sidewalls made up more than 60 percent of all passenger-car tires, and the outlook is for a continuation of this upward trend.

Tubeless passenger-car tires, which began to replace the tube-type tire in 1955, accounted for 92 percent of total passenger-car tires in 1964, and the outlook is for even wider use. Despite the decline of the tube-type passenger-car tire, output of tubes for passenger-car tires has been fairly stable in recent years. Since unit labor requirements for a tubeless tire are probably about the same as those for a tube-type

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN TIRES AND INNER TUBES



•••••••• Data for 1948 not available

Sources: Employment and expenditures, Bureau of the Census; output and output per man-hour, Bureau of Labor Statistics.

plus tube, employment effects resulting from this continuing shift are likely to be minimal.

Improved machinery is reducing process time and man-hour requirements. Automatic loading and unloading, and faster, larger capacity machinery are being used increasingly in almost all phases of production. For example, in the major operation of curing, automatic loading and unloading of the press, and adoption of molds which absorb heat more rapidly, reduce unit man-hour requirements substantially and curing time by about a fourth.

Labor savings are also being achieved by the continuing introduction of equipment which combines previously separate operations. In passenger-tire building, for example, the newest mills utilize a highly automated one-station operation with one skilled operator for combining the basic tire parts, instead of the conventional method of processing through many separate machine and manual operations. Another example is a continuous finishing mixer which can eliminate 3 of the 4 warm-up mills currently utilized in a typical tire compound extrusion process. This development is expected to reduce operating costs for labor, power, and maintenance, but may be economically feasible only for large volume production.

Improved materials-handling techniques are steadily replacing manual conveyance. Integrated conveyor systems, specialized pallets, bulk handling, and pelletization of stock are some of the techniques now reducing manual handling and promoting continuous flow line production. Pelletization, which permits both raw material and mixed stock to be conveyed more easily, is not new to the industry, but is becoming more important as mechanized handling increases. For example, carbon black prepared as pellets, rather than in powder form, facilitates bulk shipment by railroad cars, and complete conveyorized handling from car to storage tank to the mixing operation, as needed. This method of mechanized handling replaces trucking of bags of carbon black and manual loading into the mixer, reducing unit labor requirements and the hazard of air pollution.

More advanced instrumentation is rapidly developing in all areas of tire manufacture. In calendering (applying rubber compound to fabric cords), for example, radioisotope gages with feedback controls are now generally used throughout the industry to measure and control the quantity of rubber applied. Since the flow rate can be automatically set and held within extremely close tolerance limits, savings in material costs and improvement in quality can be substantial.

Centralized control of equipment and instrumentation is becoming more important as a means of increasing operational efficiency and maintaining quality control. For example, centralized control is used from raw material storage through mixing, and includes control of weighing, loading, unloading, temperature, and time. Such control systems, however, are limited to the larger modernized plants—the smaller, older mills still maintain largely manually controlled compounding and mixing procedures.

Computers are being applied increasingly to a variety of data-processing functions. Computer centers, servicing several tire plants in one area, are maintained by all major rubber companies for a wide range of routine data-processing functions such as payroll, accounting, billing, etc. In addition, these computer centers are linked to suppliers, tire plants, and larger customers, enabling the rapid collection, coordination, and analyses of data, ranging from data on raw material stock to information on marketing outlets. Use of this computer network reduces raw material and finished product inventories, permits automatic customer order receipt, enables more efficient production planning, and results in faster order filling.

Utilization of computers for scientific and engineering applications is another expanding function. Computers are being used increasingly, for example, for process optimization, including optimization of compounding formulas and of curing variables such as time and temperature. Aimed at quality improvement with minimum cost, such computer functions will grow in importance.

Plant and equipment expenditures will continue to fluctuate at high levels. Outlays for new plant and equipment rose to a postwar peak of $146.1 million in 1964, considerably above the level of the 1950's. Current indications point to continued high investments for both modernization and new plant capacity.

Manpower Trends and Outlook

Productivity is expected to continue to increase at the recent high annual rate. Output per all-employee man-hour increased at an average annual rate of 6.5 percent between 1957 and 1963, which was more than double the annual rate of 3 percent between 1947 and 1957. The annual rate of growth of output per production worker man-hour has been rising slightly faster—6.6 percent between 1957 and 1963 and 3.3 percent between 1947 and 1957. The outlook for the next 5 years is for about the same annual rate of growth as in the 1957 to 1963 period.

Employment probably will remain stable over the next 5 years. Total employment (Census data) was 85,800 in 1964 and declined at an annual rate of 1.7 percent from 1957 to 1964, about the same rate of decline as that from 1947 to 1957. In the most recent years, however, employment has been relatively stable with an annual decline of only 0.2 percent from 1961 to 1964. The outlook is for a continuation of this stability in employment over the next 5 years, as lower unit labor requirements permit increased production with little change in employment.

Average annual percent change	
All employees	
1947–57	−1.8
1957–64	−1.7
Production workers	
1947–57	−2.1
1957–64	−2.1
Output	
1947–57	1.0
1957–63	4.1
Output per all-employee man-hour	
1947–57	3.0
1957–63	6.5
Output per production worker man-hour	
1947–57	3.3
1957–63	6.6

Production worker employment will show little if any change. Production workers constituted 77 percent of all employees during the period 1961–64, declining from 79 percent in 1957 and 81 percent in 1947. From 1957 to 1964, production workers declined 2.1 percent annually, the same rate of decline as that from 1947 to 1957. During the more recent period 1961–64, production worker employment was relatively stable and will probably remain stable through 1970.

The number of machine maintenance jobs is not expected to change. Improved, self-lubricating, larger capacity machinery actually requires fewer maintenance men than do older, smaller capacity machines. An increasing need will develop, however, for maintenance men with a knowledge of electronics, hydraulics, and electrical control whose primary function will be to determine the cause of a malfunction, rather than to repair it. Although unskilled materials-handling jobs are disappearing in newer tire plants, multiple floor construction in older mills still requires many laborers for major trucking and hauling jobs.

Nonproduction worker employment probably will show little change. From 1957 to 1964, the number of nonproduction workers declined 0.6 percent annually compared with 0.7 percent from 1947 to 1957. Although, from 1962 to 1964, employment of nonproduction workers increased, it will probably show little, if any, further change by 1970.

More extensive use of computers probably will result in a decrease in employment of clerical personnel. On the other hand, distribution, marketing services, and research and development jobs are expected to increase over the next 5 years. Also, new jobs such as electronic and instrumentation technicians are expanding in central offices or main plants. These, however, are relatively few in number and do not increase in proportion to growth of production.

Skill requirements change as automation increases. In almost all modern plants, manual skills are being replaced by machine tending or console monitoring. Passenger-tire building, for example, a highly skilled manual job in older plants, still requires a skilled operator but his manual duties have been greatly reduced.

Technical skills are increasing in some operations. Calender and tread extruder operators, for example, must now fully understand intricate instrumentation, such as radioisotope gages, for proper adjustment. Maintenance and machine repairmen also require greater technical skill as machine complexity increases.

Some Issues and Examples of Adjustment

New contract provisions extend layoff benefits. More than 90 percent of the tire and tube production workers are in plants covered by labor-management agreements with the United Rubber, Cork, Linoleum and Plastic Workers of America, which include provisions for supplementary unemployment benefits (SUB). Recent major contract negotiations increased and extended layoff payments under these SUB provisions, and increased separation benefit payments.

Employment preference rights and retraining are provided in some contracts. At least one major contract provides laid-off employees with employment preference in other company plants when all their eligible laid-off employees have been recalled and new employees are being hired for work.

Company-sponsored maintenance training programs to retrain maintenance workers are now required, in at least one major contract, whenever the company installs new equipment or modernizes existing equipment which requires additional skill or knowledge.

Wage adjustments for mechanization are strengthened in new contracts. The 1965 major contracts clarified, and in one instance, updated the basis for determining the wage-rate adjustment for machine-controlled jobs. These adjustments protect the worker against loss of earnings as a result of reevaluation of piecework rates for jobs in which a machine, rather than the operator's skill or effort, becomes the major factor controlling output.

Selected References

Technological Developments

"Appraisal, A Technological Review of the Rubber Industry," *Rubber Age*, December 1964, pp. 389–396.

"How Much Can Akron Tell Detroit," *Business Week*, Aug. 8, 1964, pp. 94–98.

Morton, Maurice. *Introduction to Rubber Technology*, ch. 20, 1959, pp. 517–539.

Mulligan, Bill. "The Quiet Revolution in the Carbon Black Industry," *Rubber World*, July 1965, pp. 55–64.

"Radial Ply Tires Blur Tire Cord Picture," *Chemical and Engineering News*, Oct. 19, 1964, pp. 48, 50.

"Review and Preview, 1964, 1965," *Rubber Age*, January 1965, pp. 550–564.

Rubber Industry Facts, The Rubber Manufacturers Association, Inc., September 1964.

"The Next Steps for Rubber," *Rubber World*, June 1964, pp. 38–47.

Manpower Trends and Adjustments

Indexes of Output Per Man-Hour in the Tires and Inner Tubes Industry, 1947–60, Bureau of Labor Statistics, October 1962, 19 pp.

Industry Manpower Surveys: Tires and Tubes, Bureau of Employment Security, March 1964, 15 pp.

Shils, Edward B. *Automation and Industrial Relations*, 1963, pp. 233–236.

The Footwear (Except Rubber) Industry (SIC 314)

Summary of Outlook Through 1970

Footwear manufacturers are increasing their expenditures on new plant and equipment to increase production efficiency. Growing competition with foreign-produced leather footwear and foreign and domestic rubber and canvas footwear is encouraging the modernization of equipment. The introduction of manmade materials as a substitute for leather in uppers and new systems for grading lasts and sizing shoes are among the technological changes that could also result in increasing the efficiency of a wide range of production operations. Skilled as well as semiskilled and unskilled workers would be affected.

Employment will probably continue to decline. Determination of piece rates for jobs affected by mechanization will probably concern labor and management to an increasing extent.

Outlook for Technology and Markets

Production is expected to increase moderately. Domestic production of nonrubber footwear grew at an average annual rate of 0.6 percent per year from 1957 to 1964, compared with an increase of 1.9 percent per year from 1947 to 1957. Since per-capita consumption of domestic nonrubber footwear has tended to remain stable, the major factor in future production trends will be population growth. Production growth, therefore, will tend to be gradual.

Market and style trends are expected to continue to exert influence upon production techniques. Light, flexible shoes, simpler shoe constructions, and more casual type shoes, for example, aid shoe manufacturers in efforts to simplify production processes; handsewn moccasins, boots, and similar labor intensive styles, on the other hand, tend to increase unit labor requirements.

Foreign competition and competition from rubber and canvas footwear are influencing leather shoe producers to take a greater interest in technological improvements. Variations in sizes, styles and the irregularity of leather, require labor for adjusting and positioning tasks, which are difficult to automate. Despite early mechanization, footwear production remains a labor intensive industry, with up to 150 separate operations needed for the manufacture of a shoe. However, partly because of increasing foreign competition (imports expanded almost 500 percent from 1957 to 1963) and competition from low-cost rubber and canvas shoes (sales doubled between 1957 and 1963), there is much greater interest in new developments that would change traditional techniques significantly.

Introduction of manmade materials opens opportunities for use of more automatic equipment. A number of manmade materials for shoe uppers have been introduced recently. Manufacturers claim that some of these substitutes have like or better properties than leather, such as high porosity, scuff resistance, flexibility, and durability. Unlike leather, manmade materials are uniform in size and quality, permitting them to be cut in multiple layers on automatic die cutting machines. This could lead to operating economies, offsetting to a large degree the higher cost of many of these leather substitutes. Significant economic gains, however, require much longer production runs than is common in the industry at present.

Trade sources estimate that approximately 1 million pairs of shoes made from the leading manmade material were sold in 1964. The future extent of adoption of manmade materials will depend upon the success of producers in winning consumer acceptance, their profitability to shoe manufacturers, and the reaction of leather producers.

Research is underway to develop better quality, more uniform leather. Partly in response to competition from manmade materials, efforts are being made to overcome some of leather's disadvantages for automatic shoe production: its irregular shapes, imperfections, and failure to react uniformly to the stresses used in shoemaking. Such efforts may strengthen leather's position in the shoe market, which presently utilizes about 80 percent of the leather industry's output.

A new method of trimming hides proposed by the U.S. Department of Agriculture would reduce some of the processing and handling difficulties by cutting out the poorest sections of the hide before tanning. Leather would be produced in uniform rectangular shapes. Another approach would develop leather suitable for shoe uppers by breaking down raw hides into their basic fibers and reconstituting them into sheets with uniform properties. Research is underway to develop new finishes for leather to improve its properties; one such improved leather has been introduced recently.

New processes reduce labor requirements in bottoming. The injection molding machine, for example, automatically molds a polyvinyl chloride plastic shoe bottom, including heel and sole, directly to a leather or synthetic shoe upper and is particularly useful in making men's, children's, and casual shoes.

Vulcanization equipment automatically molds a complete rubber shoe bottom onto a leather or fabric upper and is adapted to making boots, workshoes and casual footwear.

These processes, by eliminating up to 30 traditional shoemaking operations, have reduced substantially unit labor requirements in shoe bottoming. Over 15 million pairs of shoes, amounting to about 2.5 percent of nonrubber production, were made by injection molding and vulcanization techniques in 1963. Shoes made by these processes are expected to gain an increasing share of the footwear market.

New techniques speed lasting operations. A recent pilot installation of thermalasting machinery, which molds a complete synthetic or leather shoe upper to a last and cements the parts together in three automatic operations, has been reported as having good results. The process, adapted to many types of shoes, combines a large number of previously separate operations, omitting tacking, stapling, and precementing. Lasting equipment combining even more operations is under development.

Heat-setting machines, utilizing automatic shoe transporters, are in somewhat more widespread use. These machines set the shape of the shoes rapidly, after they are placed on a last, by subjecting them to humid and then forced hot air. Time on the last is cut from days to hours, greatly reducing the manufacturer's inventory of lasts..

These two processes can be connected directly by conveyors, thereby greatly speeding up production.

A new method of last grading may lead to more efficient operations. One of the most far-reaching developments in footwear manufacture is geometric last grading, which is based upon the concept of changing all last dimensions proportionately by the same percentage factor with each size change. The arithmetic grading system, in general use since 1887, is based upon adding fixed increments to length, width, and girth for each size change and results in nonproportionate changes. Geometric grading allows the use of highly flexible, automatic equipment and therefore has great potential for reducing labor required for adjusting and positioning in shoemaking operations.

Two automatic machines, a heel-attaching machine and a heel-trimming machine, were introduced as part of a geometric last grading system in 1964 by a major shoe machinery firm. The positioning of the last in the machinery is controlled by a plate on the last, which allows the machines to distinguish between right and left shoes. The machines adjust themselves to the size of the last automatically. Equipment for the automatic transfer of shoes from one machine to the next will soon be available, and other automatic machinery is being developed. The firm estimates that approximately 500,000 pairs of men's shoes, using conventional shoe sizes, will be processed by geometric last grading equipment during 1965.

Production efficiency may be increased by a new shoe sizing system. A new method of shoe sizing, recently introduced by a leading shoe manufacturer, is based on statistical studies of foot sizes. The firm claims to be able to fit shoes more accurately with a 40-percent reduction in the number of sizes commonly manufactured. This system is designed to cut retailers' inventory and to increase efficiency through larger production runs. However, since traditional shoe size nomenclature is changed, the extent to which this system will be adopted is difficult to determine.

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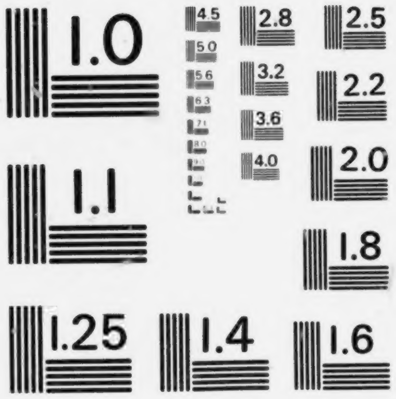
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MICROCOPY RESOLUTION TEST CHART
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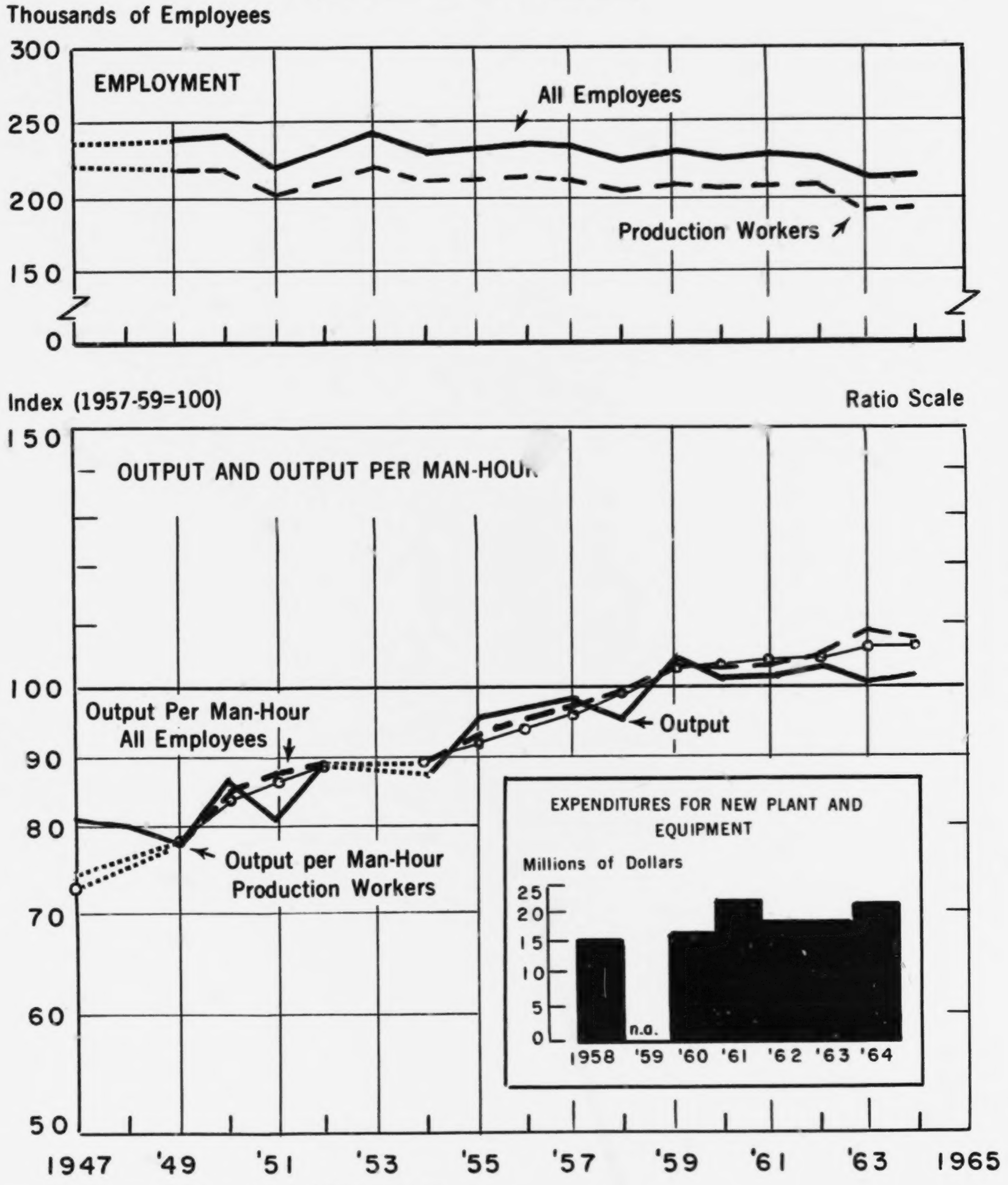
EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN THE FOOTWEAR INDUSTRY, (EXCEPT RUBBER)



············ Data for 1948 and 1953 not available

Sources: Employment and expenditures, Bureau of the Census; output and output per man-hour, Bureau of Labor Statistics.

Mechanized materials handling techniques are replacing manual methods. Conveyors are replacing the rack and basket methods of transporting work from one operation to the next. Some conveyor systems can be controlled by means of a console, with one operator directing the flow of work in a complete section, such as a stitching room. A number of firms have recently built modern, one-story plants, especially designed to utilize conveyors in conjunction with other new equipment and processes.

Conveyors are also being utilized increasingly for warehouse facilities. One large manufacturer is using computers to control a large conveyorized distribution center which can receive 50,000 pairs of shoes per day and can ship 40,000 pairs to 1,500 dealers in one 8-hour shift, with fewer than 60 employees. It can handle an inventory of 1.5 million shoes with 49,000 different size and style combinations, and it is being used to distribute the output of 17 production facilities.

New manufacturing process for casual shoes eliminates most traditional shoemaking operations. A line of women's casual shoes, introduced in late 1964, are made by means of a vacuum-forming process which shapes and forms the shoe so that the bottom and most of the upper is made from a single piece of a specially developed synthetic material. The process eliminates conventional shoe parts including insoles, sock lining, shanks, and box toes, and does not require heel seat and toe lasting.

Investment for new plant and equipment is expanding. New capital expenditures per production worker continued to remain among the lowest of all manufacturing industries, despite an increase in recent years. Expenditures for new plant and equipment were $15.1 million per year or $74 per production worker in 1958 and expanded to $21.6 million, or $112 per production worker, in 1964.

Manpower Trends and Adjustments

Moderate acceleration is expected in output per man-hour. Output per man-hour of all employees increased at an average annual rate of 2.6 percent per year from 1947 to 1957 but declined to an average rate of increase of 1.5 percent per year from 1957 to 1964. Output per production worker man-hour increased at about the same rates—2.8 percent per year from 1947 to 1957 and 1.4 percent per year from 1957 to 1964. Larger capital investments will probably quicken the pace of productivity advance.

Continued employment declines are likely. Total employment (Census) declined from 240,300 to 235,000 from 1947 to 1957, decreasing at an average annual rate of 0.2 percent. It continued to decline at an average annual rate of 1.4 percent from 1957 to 1964, dropping to an employment level of 213,300. Production worker employment followed essentially the same pattern, also declining by about 27,000 jobs in the 1947–64 period. These trends are expected to continue, leading to lower employment levels.

Occupational structure is shifting. Expanding use of manmade materials for shoe uppers and the development of more uniform leathers may lead to a decline in the need for highly skilled cutters and sorters. These occupations, mostly all held by men, accounted for 3.5 to 5 percent of the industry's production workers in 1962 and have been among the highest paid occupations in the industry.

Also likely to be affected adversely by the expanding utilization of new techniques are skilled and semiskilled workers in lasting and bottoming operations. Consisting mostly of men, these employees accounted for nearly 30 percent of all production workers.

	Average annual percent change
All employees	
1947–57	−0.2
1957–64	−1.4
Production workers	
1947–57	− .4
1957–64	−1.3
Output	
1947–57	1.9
1957–64	.6
Output per all-employee man-hour	
1947–57	2.6
1957–64	1.5
Output per production worker man-hour	
1947–57	2.8
1957–64	1.4

Widespread use of conveyors is expected to cut the need for floor workers, who comprised about 5 percent of total production workers in 1962. More than half of this group were women. Conveyorization is also expected to increase the productivity of other workers, such as machine operators, who formerly had to spend much of their time in handling materials and moving work in process.

Since many of the traditional shoe processes and construction methods will continue, some occupations will remain unaffected or will increase in employment. For example, hand stitchers for moccasins are expected to remain in demand.

Technological innovations are leading to complex problems of wage determination. New automatic equipment and processes have gradually been reducing the need for manual skills. Since about 70 percent of production workers are paid on an incentive basis, complicated problems of piece-rate determination will probably arise in the future as production processes become more machine oriented.

Recent labor-management agreements give job preferences and wage guarantees to workers affected by technological change. A contract covering 7,000 workers in New England, for example, stipulates that employees who are displaced are to be given preference in assignment to jobs on the new or improved machinery. An added provision gives preference to affected employees for any job opening in their department. This contract also provides that previous average hourly earnings are to be guaranteed to employees required to use new or improved machinery when utilizing the same or less skill. New wage rates are to be negotiated if higher skill is required.

An agreement with a major multiplant firm, with headquarters in the Midwest, covering about 22,000 workers, provides that the old pay level will be maintained for workers on a new machine until new piece rates are negotiated.

Selected References

Technological Developments

"A Computer Ships the Shoes," *Business Week*, July 11, 1964.

"A New Shoe-Sizing System," *Boot and Shoe Recorder*, Oct. 15, 1964, pp. 37–40.

Boot and Shoe Recorder, June 1, 1964, 120 pp. (shoe technology issue).

Bright, James R. *Automation and Management*, Harvard University, Graduate School of Business Administration, 1960, pp. 30–38.

Footwear News, June 4, 1964, 68 pp. (Footwear Management Conference issue).

Thompson, John W. and Poats, Fredrick J. *Economics of Segmenting Cattle Hides*, ERS Report 215, U.S. Department of Agriculture, 1965, 18 pp.

Thornton, J. H., Editor. *Textbook of Footwear Manufacture*, London, Temple Press Books Ltd., 1964, 615 pp.

Manpower Trends and Adjustments

Indexes of Output Per Man-Hour, Footwear Industry, 1947–63, Bureau of Labor Statistics, July 1965, 17 pp.

Industry Wage Survey, Footwear, April 1962, Bulletin No. 1360, Bureau of Labor Statistics, 1963, 71 pp.

Livernash, E. R. "Collective Bargaining and Competitive Cost in the Shoe Industry," *Monthly Labor Review*, March 1957, pp. 310–315.

Shulz, George P. *Pressures on Wage Decisions*, John Wiley and Sons, Inc., 1951, 142 pp.

Railroads (SIC 401)

Summary of Outlook Through 1970

Output per man-hour is expected to continue rising as expenditures for modernization expand. New developments in technology will include more powerful locomotives, rolling stock of greater capacity and specialization, advances in the unit train and piggyback, and higher speed passenger trains between densely populated areas. Improvements in track and roadbed construction and in maintenance equipment, construction materials, and structures are expected to bring further reductions in maintenance. Additional improved centralized traffic control (CTC) systems and electronic classification yards; microwave and other communications improvements; computers for traffic control; and more pools of specialized equipment are expected to advance efficiency in traffic handling and equipment utilization.

Although employment reductions will continue, the rate of decline is expected to slow down as freight traffic increases in the late 1960's. The impact of reductions in employment on account of technological change will be eased by recourse to normal attrition and payment of separation allowances, as provided for in recent collective bargaining agreements.

Outlook for Technology and Traffic

Increases in total revenue traffic are expected to continue. Between 1947 and 1957, the Bureau of Labor Statistics index of combined passenger and freight traffic declined at an average annual rate of 1.1 percent. For the period 1957 to 1963, the average rate of increase was only 0.5 percent but from 1961 to 1963, traffic increased by almost 12 percent. The estimated ton mileage for 1965 approaches the peak levels of World War II.

An increase in freight traffic is expected by 1970, and the Association of American Railroads (AAR) anticipates a rise of about one-third by 1975, assuming that railroads maintain their relative share of intercity traffic and that national economic growth trends are maintained. Freight traffic increases are expected to more than offset continued declines in passenger traffic, although commuter traffic and high-speed trains serving densely populated areas may increase passenger volume for some carriers.

Piggyback service has been called "the most significant recent development in transportation." Piggyback, or trailer-on-flat-car (TOFC) service, combines the more economical long haul of the railroads with the greater flexibility and economy of motortrucks for short distances. From about 45,000 flatcars loaded with trailers or containers in 1954, the 1964 total had reached almost 900,000. According to AAR, piggyback car loadings could reach 20 percent of total car loadings in 1975, compared with 3 percent in 1964.

TOFC technology includes specially designed flatcars, tunnel and track reconstruction, and the design of terminal facilities for high volume TOFC loading and unloading. The American Standards Association has established standard container sizes which will permit easier interchange between railroad and other modes of transport. Trailer Train, an organization of 40 railroads, has pooled thousands of TOFC cars for improved service and higher rate of car utilization. Trains of TOFC-loaded flatcars operate on expedited schedules.

Fewer workers per truck are required for a piggyback train than for individual truck-trailer movement. In addition, TOFC transportation requires less packing, bracing, rehandling and clerical labor; generates fewer loss and damage claims than boxcar shipments; permits rail service to off-track shippers; and results in greater flexibility, speed, and dependability.

Substantial modernization was effected in the postwar years, and a rising rate of improvement expenditure is indicated over the 10-year period, 1965–75. Between 1946 and 1965, the railroads invested more than $20 billion in capital improvements, averaging about $1.1 billion annually. Capital expenditures amounted to $1.4 billion in 1964, and are estimated at $1.6 billion for 1965. The industry (AAR) has announced, as a goal for the 10 years, 1965–75, expenditures of $2 billion or more annually, about three-fourths of which would be applied to improvements in motive power and rolling stock.

A new generation of diesel locomotives is expected to result in better train performance. Another generation of diesel-electric locomotives, now being delivered, ranges between 2,500 and 6,000 hp., compared with 1,200 to 1,500 hp. for earlier diesels. It is estimated that 14,500 new diesels could replace the 30,000 old units and handle the current (1965) volume of traffic. Savings in maintenance and operating labor could come, not only from the operation of fewer locomotives, but also from the lower maintenance and operating costs per unit that are claimed for the new diesels. These effects, however, would be reduced if shorter trains with higher hp. locomotives were run on more frequent schedules. Traffic growth, at any rate, is expected to require a substantial number of additional diesels by 1975.

Twenty-one diesel-hydraulic locomotives—18 of which were made in West Germany, three made in the United States—are in experimental use, but only on one railroad. Diesel hydraulics are said to be advantageous for heavy hauling on steep grades, and in high speed mainline freight service; reduced maintenance requirements are claimed. One carrier is seeking to adapt a 15,000 hp. aircraft jet engine to a locomotive, a power potential considerably beyond present diesel technology.

Larger, more diverse, and more durable rolling stock is available. With the design of better rail, axles, wheels and trucks, load limits on rails have been increasing, allowing rolling stock of greater capacity. The use of aluminum and light weight steels has allowed net weights to rise relative to gross weights. Examples are cars of 100-ton capacity compared with earlier capacities of 50 to 70 tons; tank cars in which the standard capacity—formerly 8,000 to 10,000 gallons—is now 30,000 gallons; flatcars,

Retarder operator controls the speed of coasting freight cars in classification yard.

formerly 45 to 80 feet in length are now 85 to 90 feet and carry two highway trailers or van-containers. Conventional 50- and 70-ton coal cars are being replaced by cars of 85 to 100 ton capacity. A new car for coal and other bulk materials has been built with a 7 to 1 ratio of loaded to empty weight in comparison with the 2.6 to 1 ratio for earlier equipment.

Specialized cars include center discharge cars for powder and pellets, special log cars, lumber tie-down cars, and special racks to fit the longer flat cars for automobile loading. New methods of construction, providing all-door boxcars, special flooring, and lining, facilitate loading and unloading and reduce maintenance. The use of gravity for unloading bulk materials from hopper cars has been joined by pneumatic and pressure differential type unloading devices. One carrier now offers 40 different cars, compared with 8 in 1940.

The unit train is an outstanding example of specialization. Unit trains use from 72 to 125 cars per train and haul from 7,000 to 10,000 tons of a single commodity from one large producer to one large consumer at sharply reduced rates. Unit trains travel at near passenger train speed and by-pass classification yards. With the elimination of uncoupling, switching, and weighing en route, and with the achievement of fast turn-around time, very considerable savings have been realized. Some unit trains are weighed automatically while coupled and in motion, with significant savings in labor.

While the most frequent use of unit trains is in hauling coal to utilities, they also haul grain, ores, cement and steel slabs. Many other commodities also are being considered for unit train transport. Some authorities believe that unit trains made up of the new 30,000-gallon tank cars could transport petroleum products more economically than new pipelines and save on pipeline construction.

Advanced unit trains, called "integral trains," are owned by several electric utilities. Railroads furnish motive power and right of way. Cars of the integral trains are semipermanently coupled and can be unloaded, two at a time, by rotary dumping devices. These trains are said to produce still greater bulk transport economies.

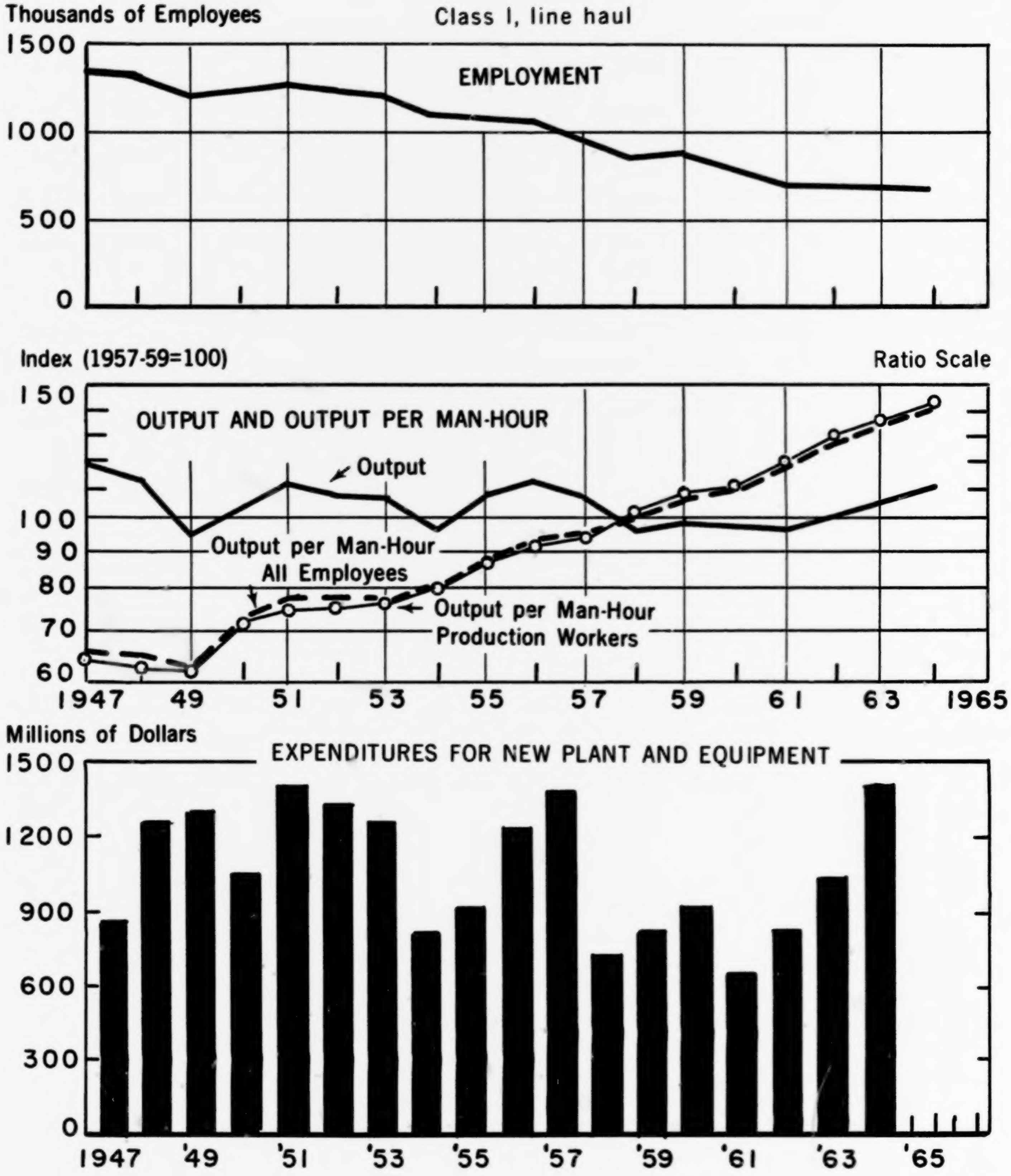
Electronic yards speed freight classification for transshipment or local delivery. Electronic yards were first installed in the United States in 1952. By 1965, nearly 60 were in operation, but only a few are fully automatic. In fully automatic yards, preprogramed digital computers record the speed and weight of cars, operate switches, apply retarders, and route the cars to the appropriate trains. Semiautomatic yards require an operator to switch the cars while an analogue computer operates the retarder system. Older yards have manually operated electro-pneumatic retarders and switches.

Electronic yard laborsavings accrue from the consolidation of several yards into one, bringing drastic reductions in the number of employees and time required for switching operations both in the consolidated yard and in other yards. Savings also result from reduced damage due to rough handling of cars, and from release of land for other purposes.

The latest development is the "economatic" yard—a semiautomatic yard to replace small, flatyards which cannot be economically incorporated into larger electronic yards. These small, semiautomatic yards are said to serve up to 10 classification tracks, and can handle a maximum of three cars a minute, more than double the switching rate of a flatyard, but less than half that of a large yard. Only two such yards were in operation in mid-1965, but the manufacturer estimated that the industry could accommodate 150 of these yards.

Centralized traffic control (CTC) circuits are becoming more refined and mileage is increasing. Under CTC, a single operator at an electronic console controls the simultaneous movements of all trains within a block of hundreds of miles of track. Trains may be handled without prior scheduling or train orders. First installed in 1927, CTC covers over 35,000 miles of railroad (nearly 30 percent of mainline mileage), almost half of which was installed after 1952. CTC reduces directly the need for train dispatchers, towermen, and telegraphers. Maintenance labor is curtailed because of reductions in track and roadbed. CTC cuts down train delays, makes possible higher average train speeds, and contributes to improved safety.

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN RAILROADS



Sources: Employment, output and output per man-hour, Bureau of Labor Statistics; expenditures, Securities and Exchange Commission and Department of Commerce.

Modern CTC units have greater capacity than earlier systems (i.e., control of more traffic over greater mileage) and permit fully automatic train meets (switching to proper tracks). Some have transistorized circuits and are equipped to receive train control signals from a digital computer.

Improved control systems (CTC, automatic classification yards, etc.) indicate the possibility of automated railroads. Improvements in train control, such as CTC and automatic classification yards, suggest the eventual control of train movements by computer. One railroad vice president claims that computerized control of crewless trains will be possible within 5 to 10 years.

In a few simplified situations, automated trains are currently being operated. Iron ore trains in Labrador and in Western United States, for example, are now operated automatically (without crew) over short distances. Japan's Tokaido Line between Tokyo and Osaka operates semiautomated trains. Thirty-five and 76-car automatic trains were successfully tested (1960) over a 10-mile mainline section of a Canadian railroad which includes a variety of curves and grades. Rapid transit trains with automatic controls are being built for the San Francisco area (scheduled for completion 1970–71). A computer will initiate makeup and dispatching of trains, determine speed, halt a train at a specified position, cause it to leave the station, and in case of delays, reschedule trains to prevent disorganization of established schedules.

Automatic car identification systems (ACI) are being developed. Infrared, radio frequency, microwave, or other sensing devices will read car identification numbers from a moving train, regardless of speed and weather conditions. The system, replacing existing visual identification, will store the information and, when required, transmit it for automatic transcription on tape. The system is expected to speed car tracing, checking of car consists of (train description), location of cars for maintenance, monitoring of trains, identifying captive cars, and generally aiding in freight car accounting. To become effective nationwide, one system and one type label must result.

Communications improvements are expected to be introduced widely. To meet the rapidly increasing need for a high-volume and rapid-information carrier, about 9,000 miles of microwave communications had been installed by 1964. Among other advances in communications are direct dialing telephone systems and electronic switching devices for teletype communications. Two-way radio connections are used increasingly between the CTC dispatcher and trains en route, in end-to-end train communications, in classification yards, on maintenance vehicles, and in trucks and automobiles.

Use of computers is increasing and includes more traffic operations. An AAR survey on computer use in 1965 shows that, exclusive of special-purpose machines, 44 railroads use 142 computers in 74 installations. Included in the total are 19 large scale computers, 31 of medium scale, and 92 of small scale.

Computers have been used largely for accounting and routine recordkeeping. Applications are spreading rapidly to include car location and utilization, engineering studies, market research, and inventory control. Future computer use in this area may include automated pricing and the furnishing of tariff and rate information. Computer simulation techniques are expected to be used to provide answers to problems involved in train operation, diesel servicing, yard performance, and communications network requirements.

About six roads have "real time" computer systems in various stages of planning or installation. Real time computers obtain information as it develops and process it, making it instantly available. One such system now being installed will include two of the world's largest computers, and will be applied to general operations, freight traffic, and accounting.

Improved machinery, materials, and techniques indicate continued reduction in maintenance labor requirements. More versatile equipment requiring fewer workers is replacing a first generation of maintenance machines. Examples are machines that raise and line the track and level and tamp the roadbed in a single operation; other machines pick up, clean, and return to the roadbed old ballast rock, thus saving the cost of new ballast; other units and equipment combine snow removal and track cleaning, and operate from track side, thereby minimizing interference with traffic flow.

Some carriers are experimenting with track recorder cars which analyze the roadbed condition electronically. In the future, recorder cars may automatically punch roadbed information onto a card for analysis by a computer, or feed it directly into a track maintenance machine that signals the need for the appropriate service.

The industrywide adoption of lubricating pads has resulted in a sharp reduction in the number of hotboxes. Car set-outs because of hotboxes, averaged 1 per 0.2 million miles in 1958, compared to an average of 1 to every 1.2 million miles in 1964. Most new freight cars have roller bearings which rarely overheat. Electronic hotbox detectors also have been a factor in reducing maintenance costs arising from this problem.

Other developments minimize the need for maintenance: more durable, longer service steel rails; prestressed concrete for ties, bridges, and buildings; new materials in freight car construction; improved locomotives; wireless microwave communications; use of better methods and more durable materials in construction of roadbed and auxiliary structures and in their maintenance. Continuing improvements in techniques of car servicing and maintenance have sharply reduced the equipment maintenance work force.

Emphasis on research and development is increasing. While the AAR Research Center is the focal point of railroad research, research and development also is carried on by the railroad equipment and supply manufacturing industries and most of the larger railroads. Examples of research, development and testing by the AAR Research Center are development of prestressed concrete ties and bridges, new roadbed stabilization techniques, surface hardening of rail, butt welding of continuous rail, hotbox prevention and detection, coupled in-motion weighing, improved lubricating materials, cushioned underframe cars, packaging methods that minimize breakage of glass containers, and methods of eliminating damage to contents of other containers.

Substantial benefits are expected from a major research and developmental program in the technology of high speed ground transportation, now underway. Recent legislation authorized research on a wide range of problems. Several demonstration projects are scheduled. One demonstration project authorized by the U.S. Department of Commerce between Washington, D.C., and New York City is being planned. Plans call for self-propelled cars, capable of operation at speeds up to 160 m.p.h. to be operated at 100 m.p.h. during the demonstration program. Funds have been provided for a stretch of road between Trenton and New Brunswick, New Jersey, to test track, catenary, and equipment at speeds up to 160 m.p.h. Another project between Boston and Providence is under consideration.

Manpower Trends and Adjustments

Output per man-hour will continue to rise. Between 1947–57, output per production worker man-hour rose 47 percent, increasing at an average annual rate of 3.9 percent. Between 1957 and 1964, the annual rate of increase rose to 6.2 percent, output per man-hour rising 53 percent over the 7-year period. Increased utilization of capacity, more advanced equipment, and recent changes in work rules could accelerate the rate of increase in the 1965–75 decade.

	Average annual percent change
All employees	
1947–57	−3.1
1957–64	−5.5
Output	
1947–57	−1.1
1957–64	.5
Output per all-employee man-hour	
1947–57	3.7
1957–64	6.0
Output per production worker man-hour	
1947–57	3.9
1957–64	6.2

Long run decline in railroad employment is expected to continue but at a slower rate than in the past. Between 1947 and 1957, employment declined from 1.35 million to 0.98 million; the decline between 1957 and 1964 amounted to 320,000 with total employment in 1964 at 665,000. The total postwar decline was 687,000 workers, a rate of about 4.1 percent a year. Despite rising productivity, offsetting growth in rail traffic may hold future employment declines below past rates.

Additional changes are imminent in occupational structure. Between 1954 and 1964, mechanization of track maintenance reduced the number of roadway and structural maintenance workers by 50 percent, from 199,000 to 99,000. Improved machinery is expected to result in some further curtailment in maintenance employment.

Reflecting the expansion in centralized traffic control, employment of train dispatchers, towermen, and telegraphers, between 1953 and 1964, declined by 36 percent, from over 42,800 to 27,500. Over the same period, employment of yard brakemen and helpers declined by 19 percent, reflecting the impact of automatic classification yards. Electricians declined by 21 percent and machinists by 35 percent. Every category of equipment and stores maintenance worker declined.

The total number of operating employees, although declining slightly in absolute numbers between 1954 and 1964, rose from 23 to 28 percent of total railroad employment. Possible settlement of work rules, the increased pace of modernization, continued decline of passenger service, and the prospect of mergers would appear to mean declining employment opportunities in train service.

Work rules dispute was temporarily halted in 1964. A May 1964 ruling in the arbitration award of November 26, 1963, permitting the railroads to remove firemen from freight and yard diesels, halted at least temporarily a dispute that had lasted from 1959. This award expires in April 1966, and eventual disposition of the problem is uncertain. Of 15,000 firemen displaced, many were retired, promoted to engineer, received other railroad jobs, or obtained jobs in other industries. The majority of the firemen not placed in other railroad jobs received severance pay. Most of those who became unemployed were also eligible for weekly unemployment benefits. Eventually, additional jobs of firemen will be eliminated, but expectations are that future reductions in force will be effected by attrition. Displacement of as many as 20,000 additional operating employees has been the subject of negotiations between the unions and individual railroads.

Attrition and severance pay are to cushion displacement effect of new technology. Many railroad management and labor agreements negotiated since 1961 have provided that, except under certain conditions, all reductions in force would be met through retirements, quits, or other normal attrition. In other cases, where employees are adversely affected by technological change, severance pay is allowed. The agreements affect both operating and nonoperating employees, and include provision for joint development of training programs to facilitate replacement of separated workers within the industry. Some of the agreements limit the rate at which jobs can be reduced, even as a result of attrition.

The Railroad Retirement Board operates employment service for railroad workers. In 1964, 26,000 jobs were found for unemployed railroad workers through the Board's placement service, about 10,000 of which were nonrailroad jobs. In the same year, a total of 6,400 transfers were reported under the partnership transfer program, a cooperative effort of railroad labor and management, begun in 1956. In May 1964, the Retirement Board began a special program to find jobs for workers displaced as a result of the work rules dispute.

Railroad workers get first choice of new railroad jobs. Some railroads have retraining programs to help railroad workers qualify for jobs requiring new skills. Because of their previous experience, retrained railroad workers were thought to be somewhat more efficient in these new jobs than workers new to the industry.

Selected References

Barriger, John W. *Super Railroads for a Dynamic American Economy,* New York, 1956, Simmons-Boardman Publishing Corp., 91 pp.

Behling, Burton N., and others. *A Review of Railroad Operations,* Washington, D.C., Association of American Railroads, Annual.

Blake, Bond. "Four Views of Train Control," *Control Engineering,* Dec. 7, 1964, pp. 62–68.

"Control Users Pinpoint the Potentials," *Control Engineering,* January 1965, p. 87.

Edwards, L. K. "High Speed Tube Transportation," *Scientific American,* August 1965, pp. 30–40.

High Speed Ground Transportation. Report 497 from the Senate Committee on Commerce to Accompany S. 1588. 89th Cong., 1st sess., U.S. Senate, July 21, 1965.

Liggett, Robert D. "The Future of Railroad Communications and Signals," *Progressive Railroading,* July–August 1963, pp. 18–23.

"Locomotives—Do More With Less," *Railway Age,* Oct. 12, 1964, pp. 39–40.

McGee, G. M. *Illustrations of Technological Improvements in Track Structures and Equipment,* Carrier Exhibit No. 23 before the Presidential Commission on Rules and Practices Governing the Assignment and Compensation of Railroad Operating Employees, 1961.

National Academy of Sciences, *Science and Technology in the Railroad Industry,* Washington, August 1963.

Railway Systems and Management Association. *Automated Information Management,* Chicago, November 1964.

Technological Change and the Future of the Railways, Evanston, Ill., The Transportation Center, Northwestern University, 1961.

Tierney, John. "Rail Logistics Favor Big Trains," *Electrical World,* Nov. 4, 1963, pp. 86–89.

"Trends in Signalling and Communication," A Special Report, *Railway Signalling and Communication,* October 1963, pp. 21–23.

The Motor Freight Industry (SIC 42)

Summary of Outlook Through 1970

Employment in the motor freight industry will continue to grow, although not as rapidly as the volume of traffic. Advances in technology and their applications will result in larger, more efficent terminals; improved engines; increasing use of diesels, particularly in lightweight trucks; specialized vehicles; and improved design and materials. Training needs will become more urgent, as equipment and regulations become more complex. The trend toward larger firms with greater capital resources facilitating modernization is continuing.

Outlook for Traffic and Technology

Continued growth in traffic is expected. Traffic ton-miles of regulated common carriers and private, nonregulated motor carriers grew annually at a rate of 5.5 percent in the 1957–64 period, compared with the higher 1947–57 rate of 9.5 percent. These carriers hauled the equivalent of 370.5 billion ton-miles in 1964 and estimates of 1970 traffic range from 470 billion ton-miles, representing an average annual growth rate of 4 percent over the period 1964–70, to 540 billion ton-miles, for an average annual growth rate of 6.5 percent.

Between 1957 and 1962 (the most recent period for which data are available), traffic ton-miles for Class I, II, and III regulated carriers grew at 5.7 percent.

The average carrier size is expected to continue growing. Common carriers regulated by the Interstate Commerce Commission (ICC) have decreased from 19,597 in 1950 to 15,618 in 1963, while the number of carriers having revenues of $200,000 or more has increased from 2,053, or 10.5 percent of the total, to 3,708, or 23.7 percent of the total.

Integrated transportation is aided by container standardization. As container sizes become standardized, motor freight transport will become more complementary to other carriers and more goods will be interchanged among motor truck, railroad, airline, and water. Unit labor requirements at interchange points could be reduced.

The trend is toward larger and more efficient terminals. Mergers frequently result in consolidation of terminal facilities in a given area, although in some situations, separately located terminals may result from attempts to give better service to a metropolitan area. One of the main features of some of the larger new terminals (approximately 100 loading doors) is the automatic dragline which, unattended, conducts carts to and from dock loading and central sorting areas. Men working on the loading docks now have the shipments brought to them automatically, saving time in truck loading.

Less-than-truckload (LTL) traffic is being handled more efficiently. LTL traffic in 1964 made up 18 percent of total tonnage (significantly higher for common carriers) and accounted for about 60 percent of total shipments and 37 percent of labor costs. By using cargo cages (containers combining small LTL shipments), carriers obtain large increases in pounds handled per man-hour. One man can unload a trailer of cages in less than one-half the time required for these same shipments handled individually. Use of the cages is still limited, however.

To speed paperwork in terminal operations, some of the larger companies are installing computers for data processing. The future adoption of the combination bill of lading recently approved by conferences representing shippers and carriers, may permit faster billing for all sizes of carriers. The combination bill, a multipart, reproducible form, allows the carrier to utilize a single, standard document filled out by the shipper to eliminate the transcription of data from a shipper's nonstandard form to a carrier's bill of lading. Time and labor savings of 40 to 50 percent of previous costs, and additional savings from reduction in delays and misrouted shipments are possible.

All these innovations in terminal operation should reduce unit labor requirements at the terminal, an area that includes approximately 20 percent of the industry's employment.

Better design and lighter weight materials for truck bodies reduce maintenance and increase payload. Swing-away cabs and fold-away fenders allow easy access to engine and wiring areas. Aluminum and fiberglass lighten the vehicle, in some instances by as much as 1,800 pounds, at costs approximating $1 per pound above those of standard construction. An industry official estimates that over 115 million pounds of aluminum, 15 percent more than in 1964, will be used in truck construction in 1965 and that more than one-half of all truck bodies ordered in 1964 were aluminum. This trend to lightweight materials is expected to continue.

Vehicles are being specialized to meet varying traffic and operating needs. Telescoping and side-by-side lo-boy trailers allow special heavy haulers to carry missiles, huge generators (500,000 pounds), and the heavy equipment of complete production lines. Power gates that raise and lower heavy shipments to and from the trailer floor save time and labor at facilities that lack loading docks. Another trailer, still experimental, and costing about $15,000 compared to approximately $5,000 for a standard unit, uses air escaping in a thin stream from check valves in the floor to "float" palletized freight. Manufacturer tests show that one man, using this equipment, can unload 20 tons of freight in less than 10 minutes. Savings in man-hours, better load control, and less damage to shipments should result.

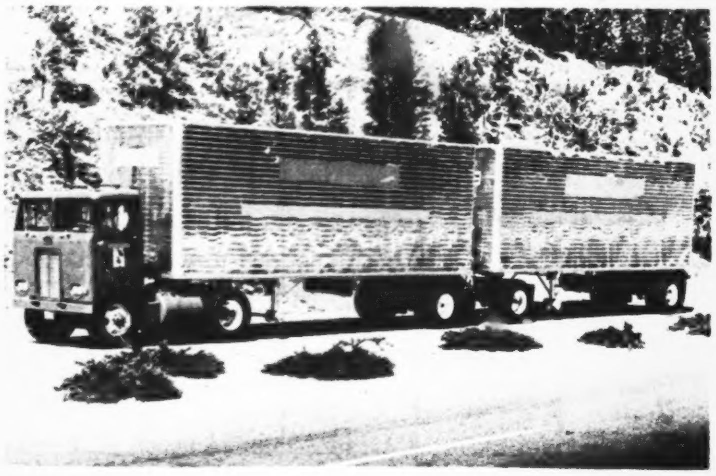
New refrigerated trucks are available that have thinner walls due to foamed-in-place polyurethane insulation instead of fiberglass. To meet performance requirements, refrigerated trucks with certified BTU performance standards are now being offered for sale. In multi-stop use, combinations of the mechanical and liquid nitrogen refrigeration systems allow quick recovery of low temperatures, mechanical components maintaining required temperatures economically.

Bulk carriage of products is increasing rapidly. Double walled pressurized tanks transport liquid gases in quantities up to 12,000 gallons at lower than −200°F. temperatures and do the job more economically than was formerly possible. Pneumatic loading is boosting the tonnage hauled in dry bulk carriage of more than 70 products, including cement, alfalfa meal, wood flour, and industrial chemicals. Pneumatic carriage of cement by truck, for example, beginning in 1958, gained rapidly, and by 1963 accounted for over 50 percent of all bulk shipments of cement in the United States.

A bulk carrier can be adapted to transport a variety of products. Tanks that can be used for hauling asphalt, for example, can haul gasoline. Other tanks can be converted from liquid to dry hauling, as in the case of molasses or grain.

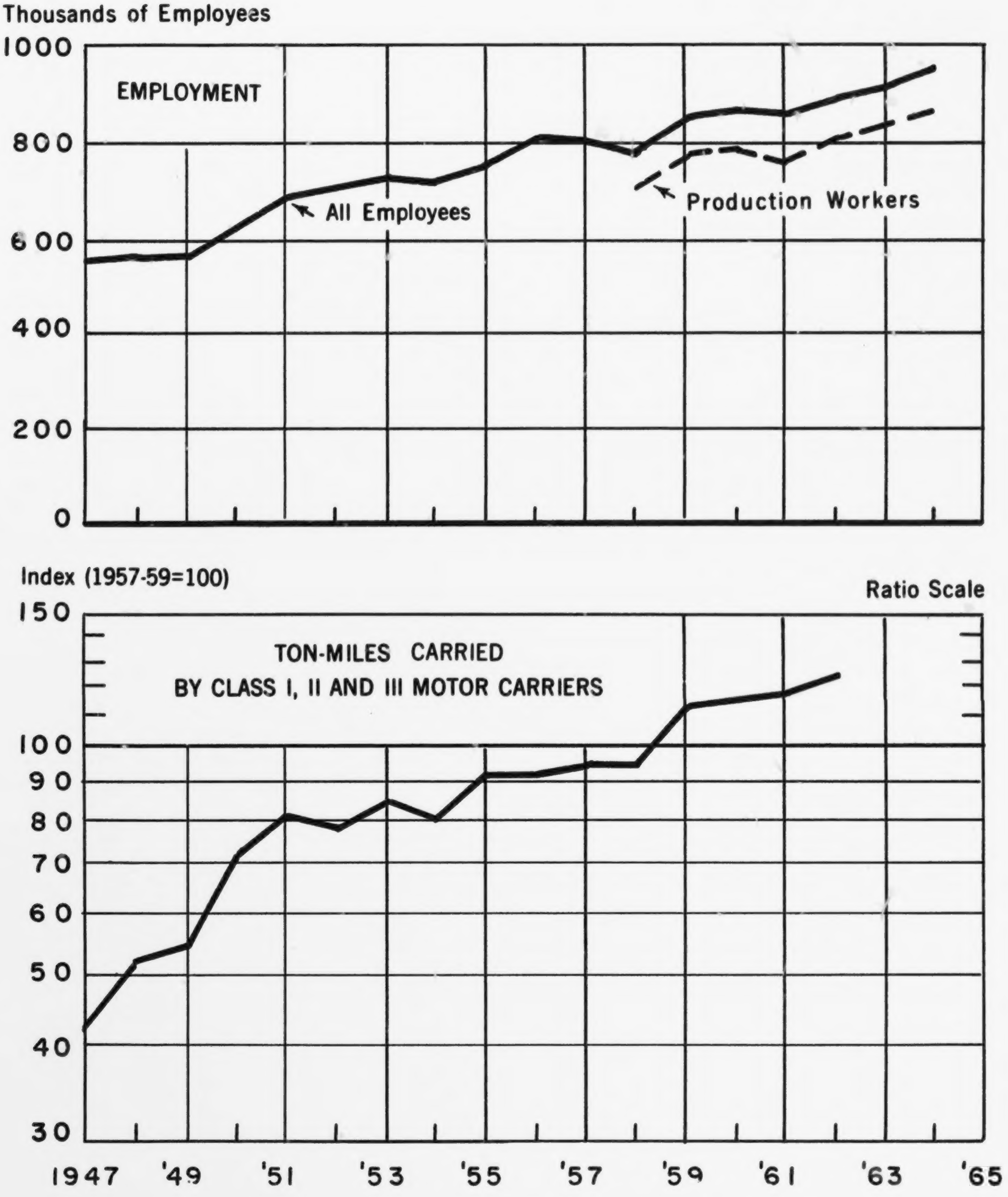
Improvements are being made both in diesel and gasoline engines. Turbo and supercharged diesel and gasoline engines provide greater power than standard engines and can be used at higher altitudes without loss of power. Changes in diesel injection systems have simplified maintenance while allowing the engine to be lightened and decreased in size, thereby making feasible their use in lightweight trucks. From 1956 to 1963, diesel truck sales increased from 2.3 percent to about 4 percent of total truck sales; sales of lightweight diesels increased faster than all diesels.

A new diesel, now being developed for medium and heavy duty trucks, is claimed by its



This 60 to 65-foot "western double" can travel as far East as Ohio before interchanging or unloading equipment.

EMPLOYMENT AND TON-MILES CARRIED IN THE MOTOR FREIGHT INDUSTRY



Sources: Employment, Bureau of Labor Statistics; ton-miles, Interstate Commerce Commission.

manufacturer to have a payload 45 percent greater than its counterpart turbo-equipped engine, and 85 percent above the conventional diesel. Diesels generally reduce fuel and maintenance costs, with savings from diesel operations estimated at $12 to $14 per 1,000 miles. A shorter period between overhauls is required for turbo-equipped engines, owing to higher operating pressures and temperatures, than for conventional diesel engines.

Advances such as increasing compression, lightweight alloy use, and new fuel injection systems, as well as recently developed transistorized ignition systems, may enhance the competitive position of the gasoline engine with respect to the diesel, particularly in the light truck field. The new fuel and ignition systems are said by industry sources to extend engine life and fuel economy. It is expected that transistorized ignition systems will be used on a large proportion of new gasoline engine trucks by 1970.

Gas turbine engines, now under intensive development, are not yet economically feasible. Continuing improvements in gasoline and diesel engines will postpone the introduction of gas turbines in significant numbers beyond 1970. Other power sources under development are the free-piston and Wankel engines.

Instrumentation eliminates guesswork from much troubleshooting and preventive maintenance. Some carriers are using spectrometers to analyze engine oil for detection of potential component breakdowns. Such analyses can prevent costly road repairs and save needless preventive maintenance, by extending intervals at which certain items must be checked or replaced under present schedules. One carrier using this type of analysis claims to have saved the price of the spectrometer ($40,000) in 1 year.

The national system of interstate and defense highways will add to efficiency of motor trucking. Forty-six percent of the system was open to traffic (19,019 miles) and work was underway on another 43 percent of the system by December 31, 1964. These roads with more lanes, better curvature and gradient, and shorter distances between points, will save commercial vehicles a total of $3 billion annually, the U.S. Bureau of Public Roads has estimated. Because of the greater strength of the new system highways, the U.S. Department of Commerce has proposed increases in allowable axle and gross vehicle weights to be effective sometime after mid-1967. These new "allowables" would mean additional savings to commercial operators.

The use of tandem trailers ("doubles") is increasing. The number of States permitting one tractor to pull two trailers in combinations 65 feet in length is increasing rapidly. States permitting these units on public highways, 14 in 1964, numbered 23 at the end of 1965. Doubles are commonly 27 to 28 feet in length; however, some doubles 40 feet in length are in operation with combinations measuring 98 to 108 feet overall. On the New York Thruway, the number of carriers operating such 108-foot doubles increased from 11 in 1963 to 26 in 1964.

Manpower Trends and Adjustments

Employment is expected to continue increasing. There were 919,800 employees in the industry in 1964 and the outlook is for a further rise through 1970. Employment grew in the 1947–57 period at an average annual rate of 3.9 percent and in the 1957–64 period at 1.9 percent. The proportion of nonproduction workers to all employment has risen from 8.8 in 1958 to 9.0 in 1964, and the increase is likely to continue. In relation to total work force, the numbers of drivers and laborers are decreasing, and sales, clerical, and managerial employees are increasing. These changes are expected to continue, reflecting increasing terminal and hauling efficiency, increasing amounts of paperwork,

	Average annual percent change
All employees	
1947–57	3.9
1957–64	1.9
Production workers	
1958–64	2.8
Ton-mile index	
1947–57	8.4
1957–62	5.7

and greater sales effort as competition with other transportation modes intensifies.

Job protection efforts involve early retirement and longer vacations. Pension ages are being lowered. Also, the number of people qualified for the 4-week vacation provided in the National Freight Agreement (1964–67) between the Teamsters and Trucking Employer's, Inc., has been expanded by lowering length of service requirements. Under that agreement, carriers will pay $5 to the Union Health and Welfare, or Pension Fund, for each trailer moved piggyback.

Selected References

Ruppenthal, Karl, ed. *Perspectives in Transportation*, Stanford University Graduate School of Business, 1963, pp. 9–15, 63–80.

"Transportation: The Age of the Specialist," *Dun's Review*, June 1964, Part II.

Whitmeyer, Marty. "Halting Rust From the Inside," *Commercial Car Journal*, June 1964, pp. 98–101.

Riddle, Holger, senior ed. "Transistorized Ignition Systems," *Fleet Owner*, August 1964, pp. 99–106.

"Unit Loads and Containerization: The State of the Art," *Transportation and Distribution and Management*, March 1964, pp. 25–35.

"Simple Motor Oil Check Increases Truck Fleet Life," *Modern Plant Operation and Maintenance*, June 1963, pp. 14–15.

"Operations Paperwork," *Fleet Owner*, March 1964, pp. 168–179.

"Driver Training Schools," *Fleet Owner*, April 1964, pp. 79–90.

"New Shop Geared for Fast Line Haul Turnaround," *Commercial Car Journal*, June 1964, pp. 80–94.

"New Truck/Trailer Developments," *Distribution Age*, January 1964, pp. 47–50.

Lyndall, Jack, associate ed. "Diesel Engines Today," *Fleet Owner*, February, June, August, December 1964, (Parts I–IV).

Hay, William H. *An Introduction to Transportation Engineering*, John Wiley & Sons, Inc., 1961.

Swart, Bernie, associate ed. "Refrigerated Truck Bodies," *Fleet Owner*, February 1964, pp. 101–108.

The Water Transportation Industry (SIC 44)

Summary of Outlook Through 1970

The maritime industry, both ashore and afloat, is undergoing extensive modernization. Major advances are being made in cargo handling, encompassing increased use of containers and bulk handling, pallets in combination with forklift trucks, particularly in the holds of ships, and pier specialization. Changes in ship design and in ship power plants, including central control and improved diesels, make possible considerable laborsavings. Atomic power for ship propulsion is expected to be limited to one ship (the N.S. Savannah) in 1970.

Total waterborne commerce (foreign and domestic) is expected to continue increasing, but the percent of foreign commerce carried by ships operating under the U.S. flag may continue to decline. Employment is expected to decline by 1970. In the longshoring section of the industry, which handles the cargo for ships of all registry, laborsavings through advancing technology may be partially offset by an increase in total commerce with only small declines in employment. Shipboard employment will reflect decreasing tonnage carried by U.S. ships, inadequate replacement of obsolete ships in the unsubsidized sector of the industry, and mechanization and automation of ships in the total U.S. merchant fleet.

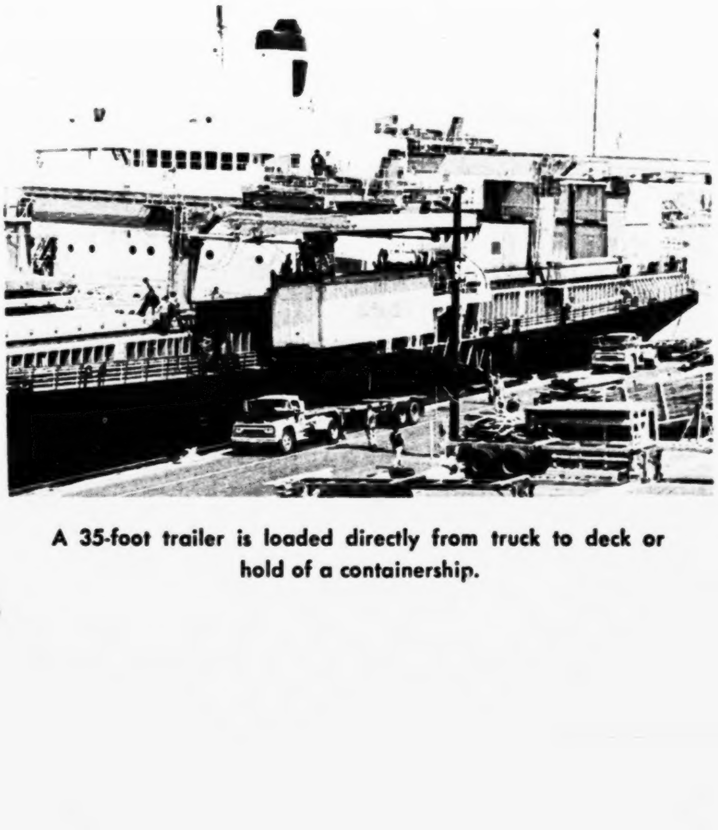
Outlook for Traffic and Technology

Foreign flag ships are carrying increasing amounts of overseas cargo. Total U.S. waterborne commerce rose from 820.6 million short tons in 1950 to 1,238.1 million short tons in 1964, an annual average gain of 3 percent. While U.S. flag operators in 1950 carried about 40 percent of the 159 million short tons of foreign trade cargo, in 1964 only about 10 percent of the total 405 million tons went in U.S. flag ships (excludes Army, Navy and Great Lakes traffic). A continuation of the decline is expected.

The subsidized fleet undergoes modernization while overall decline continues. Oceangoing ships of 1,000 gross tons or over in the U.S. registry declined from 1,145 in 1950 to 879 vessels in 1964. Of 318 vessels operating under Government subsidy in 1964, the Maritime Administration (MARAD) expects that by 1970, 200 will have new equipment either through refitting or by replacement of old ships with new, under its mechanization program.

Because foreign ships have competitive advantages in the form of lower operating costs, some nonsubsidized ships, which are primarily bulk carriers and perform nonscheduled operations, are either being transferred to foreign registry or are not being replaced when old and inefficient. In the fiscal year 1964, 64 vessels of over 1,000 gross tons were approved for transfer and 16 were actually transferred, half for scrap.

A variety of innovations reduce manning for ship operation and maintenance. In the new or retrofitted ships (ships which incorporate new controls subsequent to initial launching), central control of the power plant, including many self-regulating features and automatic control devices, may be combined with automatic data logging, reducing the number of men on watch by two (on three watches, by six). Reductions in deck and engine nonwatch personnel range from four to eight, accompanied by proportionate reductions in the steward's department. Total cuts range from 11 to 15 employees below



A 35-foot trailer is loaded directly from truck to deck or hold of a containership.

the conventional manning of 45–55. By mid-1965, 13 ships had been built with these changes. It is estimated that the cost of mechanization features may be recovered in from 1.6 to 3.8 years of operation for new ships and slightly longer in retrofitted ships.

Numerous laborsaving changes in equipment and procedures permit reductions in deck and engine nonwatch personnel. New protective coatings such as zinc silicate and epoxy paints, for example, provide protection for years instead of the months from older paints, eliminating endless rounds of chipping and painting; however, high costs of the coverings still limit their use. Redesign of rigging components is reducing maintenance. Sealed and lubricated cargo blocks are used in some ships, requiring service at 4-year, rather than weekly intervals. Aluminized wire ropes having a core lubricant eliminate time-consuming weekly applications of grease to prevent corrosion. New constant tension winches and bowthruster units allow docking operations with fewer men.

Advances are being made in power plants. New ships with more powerful engines and better design achieve speeds of over 20 knots compared with earlier speeds of 12 to 15 knots. Two vessels in the nonsubsidized fleet have the new steam propulsion unit design that reduces the need for tending equipment at sea; recent construction subsidy applications provide for incorporation of these new designs into planned ships for the subsidized sector of the industry.

New diesels for primary power have smaller space and weight requirements than older types. Industrial diesels used for ship propulsion, now turbo-charged for greater power (up to 30,000 hp.), are at an advanced stage of development. Diesels are used in many foreign and a few domestic ships.

Propulsion by gas turbine holds promise for future wider use. Turbines can be easily adapted to central control, require relatively little attention in operation at sea; their corrosion from salt air is being overcome. A few military and coast guard vessels are now powered by gas turbines.

Greater use of atomic fission for marine steam power plants appears to be at least 5 to 10 years in the future. The N.S. Savannah, now under contract for commercial operation, is likely to remain the only atomic commercial ship in the U.S. fleet in 1970, although proposals have been submitted to MARAD by several private companies for construction of additional nuclear vessels.

Through 1970, steam will be the U.S. flag operator's prime mover, with diesels and gas turbines used to power a few ships.

Significant changes in ship design reduce labor requirements in cargo handling. Some ships are constructed to accommodate special cargoes, such as lumber or newsprint. New cranes, located either on the ship or dock, handle heavier loads more rapidly and efficiently than former cranes. Cargo hatches are mechanized to speed opening and closing. A number of new ships are of "all hatch" construction so that a maximum amount of cargo can be loaded in the square of the hold by crane, eliminating much heavy labor. Roll-on-roll-off ships, primarily ferries for trailers, are in commercial and military use. More widespread future use is possible, but economic factors (decreased turn-around offset by space loss in longer trips) limit use of roll-on-roll-off ships to relatively short runs, when compared with other methods of unitization.

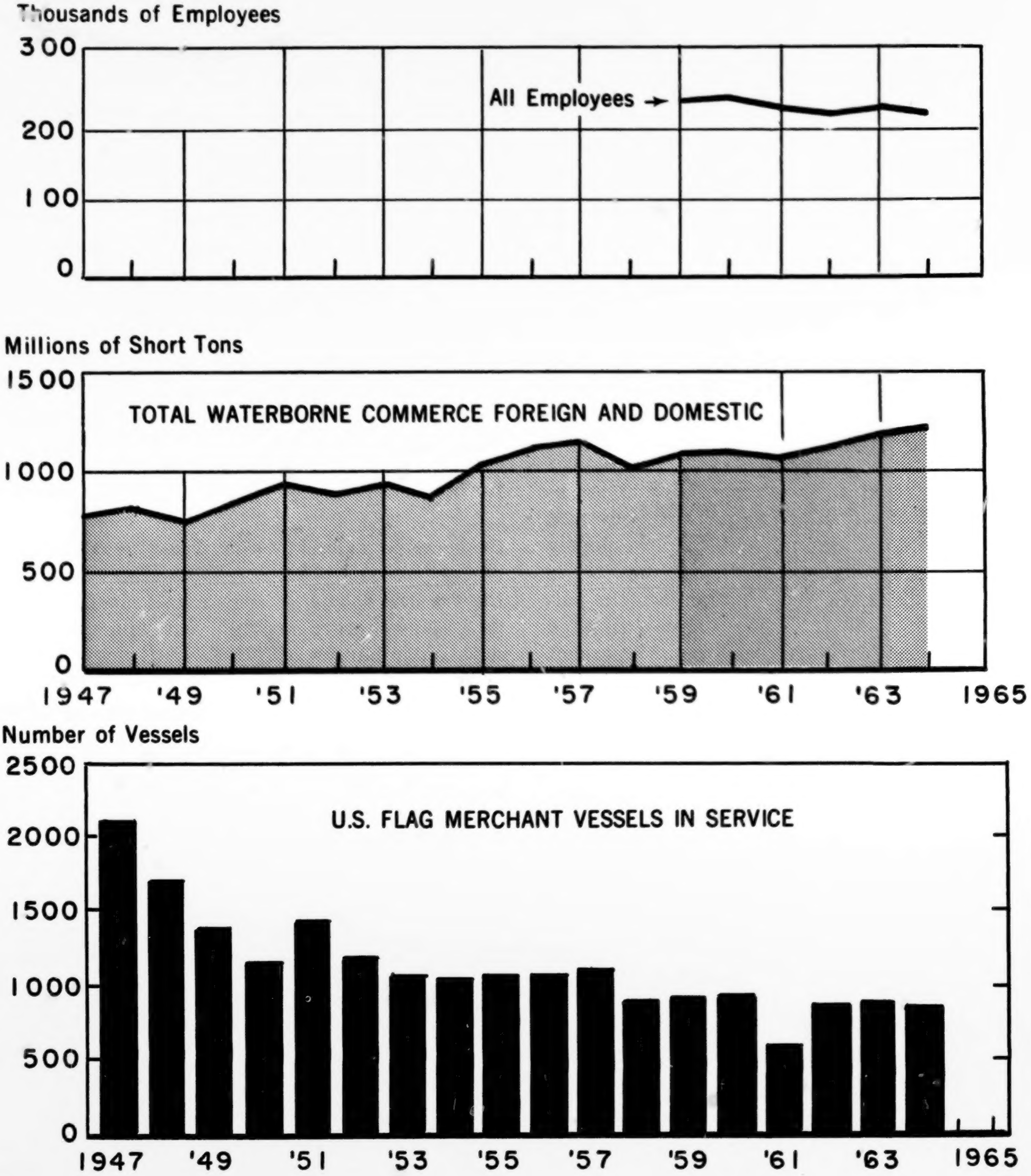
Several ship lines now use containerization extensively; 39 container ships are in operation and 10 are being constructed at the present time (mid-1965). One line carries 476 35-foot trailers in a single container ship.

A proposal to build a ship to carry small barges in transoceanic traffic is being considered, the small barges to be loaded at inland ports and floated to ocean ports for loading onto the mother ship. Lower transportation costs to and from inland ports, and the relief of some ocean port congestion would be advantages.

Cargo handling devices are being introduced to increase efficiency in loading and unloading. Specialized piers, containers, prepalletization, and new cranes all decrease cargo loading time. Pallets, in combination with forklifts, also have aided in reducing time spent in cargo handling on the piers and in the ship holds.

Special pier equipment minimizes manual handling of sugar, lumber, newsprint, and

EMPLOYMENT, WATERBORNE COMMERCE, AND U.S. VESSELS IN WATERBORNE TRANSPORTATION



Sources: Employment, Bureau of Labor Statistics; warterborne commerce, Corp of Engineers; number of vessels, U.S. Maritime Administration.

scrap. Clamshell shovels, for example, handle sugar in bulk (on the West Coast, a conveyor belt with buckets attached is used to transport the sugar); lumber is bundled; newsprint rolls are loaded using special adapters, conveyors, or specialized forklift trucks; and scrap is loaded with large magnets or through chutes.

Use of containers and pallets is expected to expand in use. Containers speed loading, eliminate losses from pilferage, reduce damage claims, and, in an all-container ship, turn-around time is cut from days to hours; however, some space is lost in loading of containers. In some all container ships, freight now can be handled by two gangs in place of the five to seven gangs often required to load "loose stow" cargo. An average gang of 18 to 20 men loads about 25 tons of loose stow per hour; a loaded container with 20–25 tons of freight can be loaded from the dock into the hold of a container ship in about 2½ minutes, increasing output per man manyfold.

Prepalletization at the shipper's plant is another method of unitizing freight. Prepalletized freight eliminates manual handling previously required to get cargo from the factory to the truck, from the truck to dock, and onto the pallet at the pier. Industry experts have estimated that in the New York area only about 5 percent of the general cargo loaded and about 3 percent of the incoming general cargo now is containerized, but future growth is anticipated, particularly in view of recently achieved international standards for container sizes and fittings. Customs complications, inadequate handling facilities in many ports, and the refusal of longshore labor in some foreign countries to handle this traffic may hinder more rapid utilization.

Hydrofoils and ground effect machines (GEM's) will be in limited use for travel over water routes by 1970. Hydrofoils, used in Europe for about 10 years, recently have been introduced into the United States to shuttle passengers in intraurban travel. Surveys indicate about 25 potential routes for hydrofoils and GEM's in the United States. A few passenger hydrofoils are being used in the United States.

Hydrofoils fly on "wings" submerged in the water at cruising speeds of about 40 or more miles per hour compared with 15 to 20 miles per hour for conventional vessels; one being tested is designed to attain speeds up to 115 miles per hour. The largest hydrofoil in use carries 150 passengers; one in the planning stage would carry up to 300.

For the GEM, gas turbines supply both the lift and directional force for the 50- to 100-miles-per-hour speed on an air cushion 3 to 4 feet above ground or water. This craft, unlike many commercial hydrofoils (some hydros have retractable foils), does not require special docking facilities and is a strong competitor on short runs for the passenger or high value cargo which both must carry to be economically feasible.

GEM service, operating two vehicles, started in 1965 in the San Francisco area for ferry service between airports, a service previously performed by helicopters. Compared to helicopters, the GEM requires less initial capital outlay, and permits lower passenger mile costs; passenger mile costs being about one-half those for helicopters.

Progress in Inland Water Transportation

Barges are becoming larger and more specialized. New barges are 195 feet long compared with older barges of 175 feet. Open and covered hoppers are the industry's basic freight units, but specialized barges such as the $750,000 cryogenic carrier are recent additions. Navigational aids, such as radar, allow boats to proceed in weather that formerly slowed or halted the tows, while increased use of radios further expedites river traffic.

Horsepower has increased in recently built tugboats. A device known as the Kort nozzle (a circular tube, built into a concavity in the hull inside which the propeller is mounted) allows the larger engines to be used efficiently in shallow draft boats, increasing pushpower as much as 25 percent. Of the tugboats (actually pushers) in use on the Gulf Intracoastal and Mississippi River systems, about 27 percent are 1,000 horsepower or more and 100 feet or more in length. A few new tugboats, 1.3 percent of approximately 1,800 boats, have diesel engines ranging from 4,000 to 8,500 hp. Larger boats with higher horsepower are expected to replace many of the older boats.

Expenditures to improve inland waterways (Great Lakes, river, and intercoastal) aid traffic growth. Projects for improved navigation of inland waterways have accounted for expenditures of more than $200 million annually from 1960 through 1964. Projects are scheduled into 1970 for replacement of obsolete locks and dams. Such improvements foster continued growth in inland waterway freight traffic which has risen in the past 20 years from 3.5 percent to 10 percent of total intercity traffic.

Manpower Trends and Adjustments

Some decline in employment is expected by 1970. Bureau of Labor Statistics employment for water transportation as of March 31, 1964, was 222,300—a decline of 9,400 from the 1959 level or an average annual decline of 0.8 percent from 1959. Four classes make up the total: deep sea transportation, Great Lakes-St. Lawrence Seaway transportation, local water transportation, and services incidental to water transportation.

Deep sea transportation employment declined slightly from 83,300 in March 1959 to 82,500 in 1964. If present labor-management negotiations allow maximum anticipated manning cuts, the total could be somewhat lower by 1970. The transfer of ships to foreign registry, and retirement of over-age ships from the nonsubsidized fleet may accelerate this decline; however, one expert feels that the composition of the work force and the attrition rate may lead to a shortage of personnel in 1970.

In local water transportation employment, traffic increases have offset greater efficiency from new laborsaving technology to stabilize annual employment at about 30,000, through the 1959–64 period.

Employment in services incidental to water transportation (about 50 percent longshoremen) has declined by 7,700 in the 1959–64 period, from 114,900 to 107,200, accounting for 82 percent of the decline in water transportation employment. Despite prospective growth in tonnage, some reduction in employment is expected in these services.

	Average annual percent change
All employees	
1959–64	−0.8
Output	
1947–57	4.0
1957–64	1.3

Employment in the Great Lakes-St. Lawrence Seaway area declined from about 4,000 in 1959 to 2,800 in 1964. The decline may be attributed to diversion of cargo to Canadian flag vessels, a decline in ore traffic, and changes in technology that allow the remaining cargo to be carried by fewer ships.

Occupational changes arise from introduction of new machinery and manning scales. Aboard some retrofitted and new ships, two new ratings, deck engine-mechanic and engineman, have been created in the shift to central control. Experience as electrician, junior engineer, or oiler is considered important for the deck engine-mechanic job; oiler, fireman-water tender, and general engineroom experience for the engineman.

Employment of crane and derrick operators, and bus, truck, and tractor drivers on the docks, and particularly in ship holds, is expected to continue increasing. Between 1950 and 1960, Census data show that the number of crane and derrick operators increased by more than 60 percent, while bus, truck, and tractor drivers increased by more than 40 percent.

Laborers (primarily longshoremen) declined in number from 58,000 to 53,000 in the same period. Expected future declines in the employment of laborers, caused by cuts in gang sizes in some ports, as provided in recent labor contracts, may be partially offset by traffic increases.

Some Issues and Examples of Adjustment

Adjustment to mechanization is a primary issue in the maritime industry. The anticipated displacement due to shipboard manning changes involves about 2,000 jobs through 1970. A mediation procedure was established in 1965 by shipowners and unions to resolve jurisdictional disputes resulting from the newly automated machinery and procedures adopted aboard recently built ships. One maritime union, negotiating for 21,000 members, obtained 60 days of paid vacation after 1 year of continuous service in the industry, up from the previous level of 60 days for continuous employment with one company or 30 days of vacation for 1 year of employment in the industry.

New pension benefits are $150 per month, up from $125 per month, effective in June 1965. These pensions, paid after 20 years of service regardless of age, are financed from the funds provided by employers through the diversion of the 25 cents per man-day which was paid into an Employment Security Fund for the period from July 1, 1963 through June 15, 1965. Retirement, with reduced benefits at age 65, is permitted for those who do not have 20 years of service.

Since June 16, 1965, the companies pay an additional 25 cents per man-day into the Employment Security Fund to aid in meeting the impact of automation. A joint committee is to be set up to investigate problems.

West Coast longshore industry Mechanization and Modernization Pact. Employers pay $5 million a year until July 1966 into a fund which is used for pension benefits, and to guarantee wages to men registered at the time of the agreement's execution. Two million of the $5 million annually paid is viewed as payment to the men for giving up rights in previously negotiated work rules.

There is a flat guarantee against layoff and, in addition, workers who receive less than 35 hours of straight-time pay in a week will be brought up to that level. To date, it has not been necessary to use the provision guaranteeing wages.

Voluntary and mandatory early retirement provisions are important parts of this settlement. Payments for early retirement are $220 per month from age 62, when retirement is permitted, to age 65, when retirement is compulsory. When the worker retires at age 65, he receives a lump sum of $7,920, equivalent to 36 monthly payments of $220. Under mandatory early retirement, agreed to in collective bargaining, workers can be retired at age 62 with 22 years or more of service. Payments are $100 a month above the $220 monthly payment due upon voluntary retirement, until age 65, when social security benefits may be drawn. The mandatory provision has not been applied.

The longshore gang size will be reduced in New York, but the force will have a Guaranteed Annual Wage. Under the 1965 agreement, longshoremen registered as of April 1, 1965, and who work a total of 700 hours or more between that date and April 1, 1966, are guaranteed 1,600 hours, or its equivalent in wages, for the duration of the contract. The Guaranteed Annual Wage was not included in other port settlements, although in Baltimore the employer group guarantees, for the contract period, contributions for a minimum of 16 million man-hours to be paid into the pension and welfare funds. The size of the general cargo gang will be reduced starting April 1, 1966, from 20 to 18, and the following year, to 17 in New York.

Training programs have been established through collective bargaining. New schools have been set up through cooperation of labor unions and steamship lines to train men for the new, centrally controlled ships. The curriculum consists of 4 weeks' academic and 2 weeks' shipboard training. Many of the 100 men who have graduated from the school have defrayed their own expenses.

For the N.S. Savannah, the engineers had special training prior to sailing. Another group received 11 months training while the ship was in operation.

Shortages of licensed engineers for recommissioned ships for defense purposes have resulted in a program by the Marine Engineers Beneficial Association (MEBA) and the Seafarer's International Union to upgrade unlicensed engineering employees to a licensed status. Under the new sytem, pension and benefit rights earned in previously unlicensed status will be credited to equivalent funds in the licensed category, so that their benefits will be paid on the basis of the combined credits. The MEBA has waived its customary $1,000 initiation fee and trainees will receive $110 per week for a period of 30 to 90 days, the duration of the training period, depending upon the amount of training required. Union officials expect that about 250 unlicensed personnel will be upgraded in the training program's first year.

In addition to the unions' programs, the Department of Labor, in cooperation with the MEBA, is studying the feasibility of establishing a program to upgrade ship engineers. The program would be financed by Manpower, Development, and Training Act funds.

Selected References

Technology

Annual Report of the Maritime Administration, U.S. Department of Commerce, October 1964.

Dillon, E. Scott; Fixman, Carl M.; and Tangerini, Caesar. *Mechanization in the Maritime Administration Cargo Ship Replacement Program,* Maritime Administration, U.S. Department of Commerce, Presented to the Joint Meeting of the Chesapeake and Philadelphia Sections of the Society of Naval Architects and Marine Engineers, Oct. 17, 1964.

Erler, Raymond J. and Weinstock, Jack K. *Technical Studies in Cargo Handling—VIII,* "Re-examination of Automated Ships," Report 61–68, University of California, Los Angeles, April 1962.

Maritime Cargo Transportation Conference. *San Francisco Port Study: Description and Analysis of Maritime Cargo Operations in a U.S. Port,* Washington, D.C., National Academy of Sciences-National Research Council, 1964, 2v. (NRC publication 1140A.)

Merchant Ship Automation Study, "Summary and Recommendations," No. [illegible]62 R 0011, Prepared by Norden Division, United Aircraft Corporation for Maritime Administration, June 20, 1961.

Progress in Cargo Handling, Volume IV—Research, Proceedings of the Sixth Biennial Technical Conference of the International Cargo Handling Coordination Association, London, October 1963, Fairplay Publications, Ltd., London, 1964.

Manpower

Fairley, Lincoln. "ILWU–PMA Mechanization and Modernization Agreement," *Labor Law Journal,* July 1961, pp. 664–680.

Groom, Phyllis. "Hiring Practices for Longshoremen," *Monthly Labor Review,* November 1965, pp. 1289–1306.

Hays, George. "Automation in the Port of Baltimore," *Employment Service Review,* U.S. Department of Labor, Manpower Administration, April 1965, pp. 23–24, 26.

Kennedy, Thomas. *Automation Funds and Displaced Workers,* Harvard University, Division of Research, Graduate School of Business Administration, Cambridge, Mass., 1962, pp. 70–128.

Kossoris, Max. "Working Rules in West Coast Longshoring," *Monthly Labor Review,* January 1961, pp. 1–10.

Shils, Edward B. "Transportation's Labor Crisis," *Harvard Business Review,* May–June 1964, pp. 84–98.

The Air Transportation Industry (SIC 451, 452)

Summary of Outlook Through 1970

Continuing increases in airline employment are expected through 1970. Rising demand for air transportation service will more than offset growing efficiency in manpower utilization. Short- and medium-range passenger craft and convertible passenger-cargo planes will be emphasized in new jet aircraft purchases. Additions to the fleet, however, will depend on the rate of growth of demand, and excess capacity may be reduced. Continuing improvements are anticipated in flight and nonflight equipment, coupled with a larger role for electronics in all areas of operation. Another round of new technology, involving both subsonic and supersonic transports and vertical or short takeoff and landing craft, is a possibility by 1975.

Prospects of shortages of technical personnel are resulting in the establishment of special training programs. Many collective bargaining agreements provide for training and retraining programs to meet the impact of technological change.

Outlook for Technology and Traffic

Growth of air traffic is projected at a high rate. A measure of industry growth, overall revenue ton-miles (combined passenger and cargo ton-miles), increased at an average annual rate of 15.8 percent between 1947 and 1957 and at the slower rate of 10.1 percent between 1957 and 1964. Current industry estimates are that passenger traffic will show, through 1970, an annual increase of 7 to 10 percent assuming continuation of favorable business conditions. Between 1962 and 1964, passenger traffic increased at an average annual rate of 15 percent, returning to its postwar level after growing at the rate of 7 percent between 1959 and 1962, the first years of the jet age. Since only a small percentage of the population now travels by air, a considerable longrun growth potential in passenger air traffic is indicated.

Revenue ton-miles of aircargo more than doubled between 1957 and 1963. Industry experts expect aircargo to grow at more than 20 percent, compounded annually, resulting in nearly 4 billion ton-miles in 1970, compared with 1.5 billion in 1963. The greater efficiency of new jet freighters in collecting, handling, and distributing cargo, is expected to stimulate significant rate reductions.

Emphasis in new passenger planes will be on medium- and short-range jets. These planes will release a number of long-range planes from short-route to long-route service for which they were designed. Some long-range planes including "convertibles," of improved design for rapid conversion between cargo and passenger service probably will be acquired. As of January 1965, 663 turbojet aircraft were on order for 1965–69 delivery, and placement of more orders was expected. The acquisitions are for additional capacity and replacement of more than 1,000 aging piston planes. In mid-1965, jets accounted for over 75 percent of total revenue mileage.

In 1964, the first three-engine medium-range jets (1,000–1,500 miles) were placed in service, and in 1965, the first two-engine short-range jets (100–1,000 miles) were delivered. These second generation jets, well suited to small airport operation, are speedier, more efficient, and will provide greater comfort than the craft they replace. Indicative of the extension of passenger service by jets is the fact that local service airlines, none of which had previously flown jets, are among the buyers of the short-range craft. Estimates are for a minimum world market of 1,000 short-range jets by 1975. (Historically, U.S. airlines have operated about 60 percent of all transport aircraft.)

An increase in the types of available all-cargo aircraft will expand aircargo service. All-cargo aircraft will fly directly between more cities. Local service airlines are converting small piston planes to all-cargo usage, medium-range jet freighters are scheduled for delivery in 1966, and the C-141 military freighter has been made available for civilian use. The C-141 is a large jet designed to carry one or more standard containers interchangeable among railroads, trucks, and ships. Loaded from the rear at truck bed height, the airplane can take off fully loaded from the 6,000-foot runways common to some 600 U.S. airports, while only about 60 airports can handle other large-cargo jets. A civilian version, with delivery possible for 1967, will accommodate a much greater volume of cargo, making possible a reduction in the cost of airfreight at reasonably assumed load factors (ratio of capacity to revenue tonnage). In 1964, U.S. airlines operated 32 jet freighters, and 38 were on order. It is estimated that 125 or more large-cargo jets will be in service of the airlines by 1970. In addition, the holds of passenger jets carry substantial cargo tonnages.

A more automated air traffic control system is due by 1975. The new system, built around radar, automatic altitude reporting devices, and electronic computers, is expected to provide semi-automated en route control of air traffic using fewer locations. Greatly improved terminal control also is contemplated. Airlines are outfitting their planes with beacon transponder equipment capable of automatically identifying aircraft and reporting altitude to ground traffic controllers. The Federal Aviation Agency (FAA) is installing, at airports and intermediate stations, modern radar that will receive and display altitude information received from planes. Other important components of the projected system, particularly the data processors, are being evaluated in pilot operations around the Nation. More advanced equipment is being tested at the National Aviation Facilities Experimental Center. The new system is expected to require fewer en route control positions, and thus cause some reduction in FAA control personnel; but increased amounts and complexities of electronic equipment may require more FAA maintenance personnel.

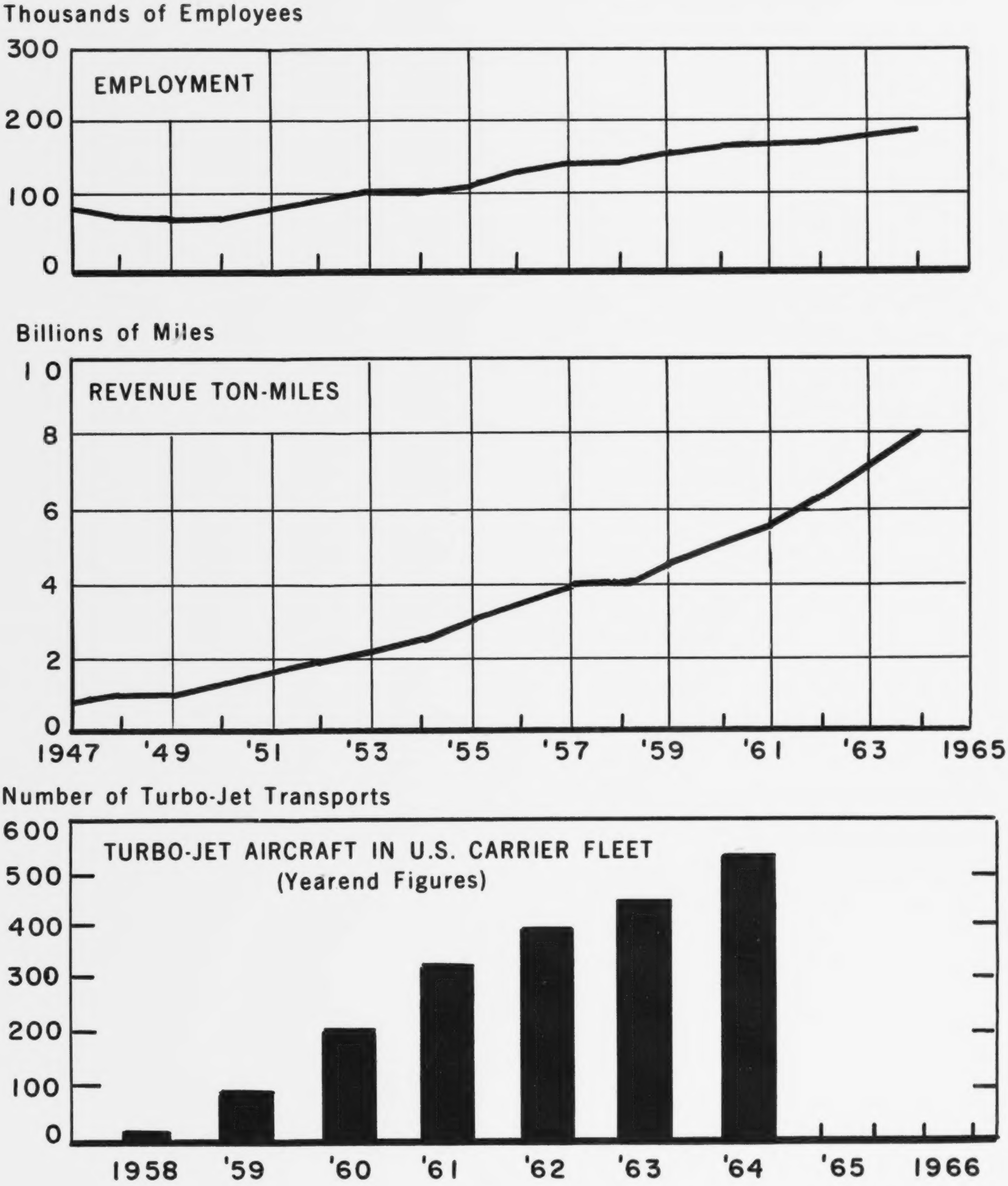
Self-contained navigation systems permit safe transoceanic flight without ground based aids. Two new self-contained navigation systems, which permit reliable aircraft orientation without contact with ground equipment, are being installed in transoceanic craft. These are Doppler radar and a system of inertial navigation based on precision gyroscopes. Both systems may provide for greater flight frequency in overseas airlanes, more efficient flight through accurate navigation, and a capability for three-man operation of transoceanic jets instead of the existing four-man crews.

All weather landing systems are being installed. Present minimum landing requirements are 200-foot ceilings and one-half mile pilot visibility. It is estimated that more than half of annual airline revenue losses, due to weather delay and cancellations, which amount to nearly $100 million, could be eliminated by halving these landing requirements. At least two airlines are testing different versions of airborne equipment (computers, radio altimeters, improved auto pilots, etc.), which, with suitable airplane qualities, permit landings and takeoffs at 100-foot ceilings and quarter-mile visibility. The equipment utilizes improved localizer and glide slope beams of the existing instrument landing system. Installation in suitable air transports may begin in 1966. Ultimate goals of ceiling zero and visibility zero at major airports appear to be a decade away, although, according to some authorities, 100-foot ceilings may be adequate.

More complex electronic data-processing and communications systems have been developed. Computers are used increasingly in all airline operations that demand data manipulation at a rapid rate or in large amounts, such as maintenance flow control, flight planning, communications switching, ticket reservations, inventory

New dimension in freight transport is marked by transfer of railway containers between truck and jet freighter.

EMPLOYMENT, REVENUE TON-MILES, AND EQUIPMENT IN THE AIR TRANSPORTATION INDUSTRY



Sources: Employment, Bureau of Labor Statistics; revenue ton-miles, The Civil Aeronautics Board; carrier fleet, Federal Aviation Agency.

control, transmission of air bills, preparation of cargo invoices, and routine accounting functions.

There are 11 new airline reservations facilities which are integrated data exchange systems that incorporate the world's largest data processors, many remote input devices, and thousands of miles of communications. These networks have enough excess capacity to accommodate considerable industry growth.

In addition to processing its own reservations, one company's system can handle 30,000 daily calls from other airlines, record the passenger's name and any special services requested; automatically advise the agent when the passenger needs to be telephoned; compile waiting lists for fully booked flights; and select passengers on a priority basis when cancellations occur. This system can maintain an automatic check on ticket-time limits; convey advice on space not likely to be used; and compute daily load factors by flight and by airport. By means of this system, management can also learn customer habits in making reservations, the percentage of total business received from other airlines, and the effect of advertising on total reservations.

Three new types of air transports now under development may dramatically increase the scale of air transportation. The supersonic transport (SST), designed to operate principally in long haul markets at speeds up to 2,000 miles an hour, will reach the earth's most distant point in only 6 to 7 hours. Many problems of engineering and economics yet are to be resolved.

Another probability is a subsonic jet with greatly improved convertibility between cargo and passenger traffic, excellent short takeoff and landing characteristics, and unique loading methods. It will be capable of carrying 500 or more passengers or 100 or more tons of cargo, and doubling as an airbus or a freighter as the need arises. With provisions for improved airport access, this jet might make airlines competitive with buslines. As a freighter, it might compete directly with trucks for many commodities on shorter ranges. Both the SST's and the airbuses (or freighters) are potentially several times as productive as today's jets.

Finally, the metroplane, a vertical or very short takeoff and landing craft (VSTOL), will probably operate between city centers (less than 500 miles apart), the distance in which most travel occurs. VSTOL craft (probably improved helicopters) also can decrease travel time between the airport and midcity and suburban concentration points which now absorbs a relatively large proportion of total trip time.

In the 1970's, air transports virtually will be flown by airborne computers capable of processing information from weather, navigation, and traffic control satellites. The flight crews' principal function likely will be to monitor the system and take over in emergencies. Radio reporting will be largely automatic, eliminating human reaction time, and freeing the pilot for other duties. Collision avoidance systems may be developed to advise the computer (or pilot) of potential collision and suggest corrective action.

Rise in expenditures for plant and equipment is expected to continue. Between 1958 and 1963, the airlines spent more than $3 billion, primarily for new jet aircraft and ground support facilities. Expenditures averaged more than $500 million a year compared with around $225 million between 1950 and 1958. These trends are expected to continue at an even faster pace. Aircraft valued at $3.7 billion are scheduled for delivery after 1964, and additional orders are expected.

Manpower Trends and Adjustments

Continued rapid growth of employment is expected. Between 1947 and 1957, employment in air transportation grew at a compounded average annual rate of 6.2 percent, rising from 82,000 workers to over 148,000. In the 1957–64 period, the growth rate slowed to 3.7 percent annually, reflecting the impact of rapidly advancing technology. Employment in 1964, nevertheless, exceeded 190,000. Jet age employment has been characterized by alternating periods of rapid and slow growth. Of 42,000 workers added since the first jet was flown, 23,000 were added before 1960 and 10,000 after 1963. In the future, growth is expected to stabilize at about 4-percent-per-annum, with

	Average annual percent change
All employees	
1947–57	6.2
1957–64	3.7
Revenue ton-miles	
1947–57	15.8
1957–64	10.1

the level of employment approaching or exceeding 300,000 by 1975.

Increased employment is accompanied by occupational change. A few occupations have disappeared; many others are shifting in relative importance. Jobs of navigators in transoceanic flight and flight engineers on jet aircraft, for example, are being eliminated and the workers retrained as pilots. Communications operators' employment is declining as the result of more advanced radio and telecommunications. Flight deck employment first declined as jets replaced a larger number of piston planes, but an upsurge in passenger traffic after 1962 required additional aircraft and higher daily utilization rates and resulted in increased flight deck employment.

Increases in field maintenance and overhaul shop employment and shifts in employment composition, involving fewer engine overhaul mechanics and more airframe and systems mechanics, reflect both the increased simplicity and reliability of the jet engine and the increased complexity of the electrical, electronic, hydraulic, and other aircraft systems. Airfreight sales and handling personnel may well grow rapidly. Other airline employment may increase somewhat because of the growing demand for air transportation and increasing size of the industry.

Length and degree of training are increasing. The airlines required 10 hours of training to transfer a pilot from a small to a large piston plane, but shifting that same pilot to a more complex jet requires from 20 to 50 hours of training. The initial costs of training cockpit personnel of piston planes to make the transition to jet aircraft was many millions, exclusive of the costs of new training equipment and periodic rechecks.

Increases in training requirements also affect a wide range of other operations including flight planning, fuel management, emergency procedures, maintenance, and ground operations. For example, the operators of the world's largest jet overhaul base claimed that up to 18 months are required to bring an engine overhaul mechanic to an acceptable level of efficiency, notwithstanding any previous experience.

Training and retraining is a continuous process, affecting virtually all employees. In connection with the installation of a large reservation system, for example, the jobs of 1,000 clerks and 85 supervisors were eliminated, and the employees were transferred to other jobs after appropriate retraining. Annual costs of training and retraining have been estimated at around $60 million. For supersonic planes, training will be more rigorous, and more costly.

Threatened shortages of airline technical personnel are forcing special programs. A decline in the number of persons available from military aviation (one of the traditional sources of airline flight and technical personnel) may indicate a future shortage of needed skills. The Aviation Human Resources Study Board, convened by the Federal Aviation Agency, recommended in 1964 establishment of consolidated industry training programs, use of on-the-job and apprentice training programs, and utilization of Federal vocational education programs.

Adjustments of disputes over employment of navigators and flight engineers have been made. The introduction of jetplanes and new navigational devices led to disputes over employment of navigators and the three-way conflict between the airlines, the pilots, and the flight engineers over the rights and duties associated with the third seat in the jet cockpit.

One agreement provided for the ultimate replacement of navigators by automatic equipment. The displaced employees were allowed severance pay and continued participation in group hospitalization insurance and pension plans. Another agreement provided that flight engineers, after training, should have prior rights to employment as pilots or could accept severance pay and continued participation in group life and medical insurance plans and pensions.

New agreements have been reached on manning the shorter range jets that utilize two-man cockpit crews. The shorter range jets are replacing DC-6's and DC-7's which are manned by three men. It was estimated that 52 small jets would eliminate about 250 jobs, the number increasing as the number of new aircraft increases.

Selected References

Technological Developments

Booda, Larry. "New 12,000 Mile Cargo Aircraft Is Sought," *Aviation Week and Space Technology,* Nov. 18, 1963, pp. 26–27.

Craig, Thomas R. *Forecast of Free World Air Freight Traffic.* Report sponsored by the Boeing Company, Renton, Wash., April 1964.

Halaby, Najeeb E. "The Impact of the New Technology—The FAA View," in *Issues and Challenges of Air Transportation II.* Report of Symposium sponsored by the Connecticut General Life Insurance Company, Hartford, Conn., May 15–17, 1963, pp. E2–E10.

Hibbard, Hall W. "The Lift Liner, Vertical Rising Airbus of Tomorrow." Advance paper prepared as background for Symposium, *Issues and Challenges of Air Transportation* (supra).

Hoffman, David. "Big Lift For Air Cargo," *Aerospace,* June 1963, pp. 20–24.

Klavs, Phillip J. "All Weather Landing Progress," *Aviation Week and Space Technology,* October 7, 1963, pp. 169–173.

U.S. Congress, Senate, *U.S. Commercial Supersonic Aircraft Development Program,* Hearings Before the Aviation Subcommittee of the Senate Committee on Commerce, 88th Cong., 1st sess., 1963.

Manpower Trends and Adjustments

Blum, Albert A. "Fourth Man Out—Background of the Flight Engineer—Airline Pilot Conflict," *Labor Law Journal,* August 1962, pp. 649–657.

Employment Requirements and Changing Occupational Structure in Civil Aviation (BLS Bulletin 1367, June 1964).

Federal Aviation Agency. *Report of the Aviation Human Resources Study Board on the Manpower Requirements of the Civil Aviation Industry,* Oct. 1, 1964.

O'Brien, Joseph L. "Automation and Job Security." Remarks before the Labor Relations Council of the National Chamber of Commerce, Boston, Mass., Aug. 14, 1964. (Mimeographed.)

Recent Collective Bargaining and Technological Change (BLS Report 266, March 1964), pp. 7–9.

The Telephone Communication Industry (SIC 481)

Summary of Outlook Through 1970

Telephone communications services are expected to expand substantially. Services to businesses may increase much more than services to households; long-distance and overseas calls may grow faster than local traffic. Major technological advances are taking place, including electronic switching, communications via satellites, and a wide variety of automatic equipment for operations and maintenance.

Employment may remain fairly stable or rise slightly. The number of operators, clerical workers, and employees placing wire and cable will remain about the same. Employment of highly skilled installers and repairmen who work with business communications systems, sales engineers who promote these services, and central office craftsmen will increase. Skill levels of nonsupervisory employees working with some types of the newest equipment appear to be rising. In this industry, manpower planning and training techniques have been used to adjust the work force to new equipment.

Outlook for Technology and Markets

A major expansion of services is expected. Telephones are expected to increase from 89 million in 1964 to 118 million by 1970, or at roughly 5 percent a year. Long-distance (toll) calls (5.2 billion in 1964) are expected to grow in volume faster than local calls (about 112 billion in 1964), rising about 7 percent a year to 15 billion by 1980. Long-distance calls may rise even faster, due partly to lowered rates. It is estimated that the "after nine" long-distance rate reduction in early 1963 stimulated 16 million additional calls during its first year. An increasing proportion of operating revenues is coming from special equipment and services such as dataphone and private-line services. In 1964, these amounted to 25 percent of operating revenues; a decade previously, only 10 percent.

A variety of communications services to business is being introduced. Private switched networks for voice and data are already installed in a few large corporations and the Federal Government; by 1970, approximately 45 to 50 will be in service. Businesses using regular telephone facilities can obtain service packages which include direct long-distance dialing from any extension, incoming calls dialable to any extension, conference calls, internal dictation systems using extension lines, paging and alarm systems, devices to distribute calls among a number of answering attendants, and automatic data transmission from remote input stations to central computers.

Telephone facilities for television transmission, including smaller closed-circuit facilities for banks and retail stores, are also increasing. Picturephone service, introduced in 1964, is being used by business for sales promotion and job interviews. New pushbutton telephones, first installed in 1963, will eventually be able to connect households with receivers and computers in banks, retail stores, and other businesses. By 1970, individuals using the pushbutton telephone may be able to order merchandise, pay bills, make inquiries, and handle other business transactions by communicating directly with computers or related business machines. Order takers, salespeople, and other clerical workers in retail trade and service industries may be affected.

Very rapid growth will take place in data communication. Data and facsimile transmission enable businesses to link warehouses with sales offices, to make and confirm reservations at any number of remote locations (hotel and transportation systems), to transmit data from regional offices to a central computer (insurance companies, banks), or to set type at a remote printing plant. In 1965, data communication installations are expected to total 40,000 sets, and a rapid increase is in prospect.

Capacity of carrier systems is being greatly expanded by developments in transmission, requiring less construction for each "conversation." Microwave carrier systems have increased rapidly; they now carry half of all interstate long-distance communication. Most importantly, the capacity of existing cable and microwave routes is being expanded many times by new transmission techniques, such as time division multiplexing which squeezes more conversations into each circuit. Advances in frequency division multiplexing are also expanding transmission capacity. Currently experimental, millimeter waveguide and laser (light beam) transmission have a potential capacity of thousands of times more circuits than the most advanced present carriers. However, because they are affected by weather, current predictions for prototype waveguide systems by the late 1970's (or laser systems by the early 1980's) envision underground or undersea tubes to carry the beam.

Capacity for overseas telephoning is being expanded rapidly with growth in U.S. world trade. Transistorized ocean cables, six times larger than cables laid last year, are planned for 1968 —but will not be laid if satellite relay systems are fully operating. By 1980, some industry experts predict that satellite relay systems (requiring a few ground stations, but no cables) will be transmitting two-thirds of the international traffic, which is expected to increase twentyfold. The satellite will be able to relay broadband microwave signals, permitting television, data, and voice transmission.

Electronically switched central offices will permit a wide variety of new services and economies. Electronic switching, serving over 65,000 lines in 1965, will be extended to nearly 30 percent of all lines by 1975. Service changes can be made simply by altering circuit "memory," which now can be done only by physically altering and rewiring equipment. Under certain circumstances, electronic equipment takes up only one-fifth the space required for present electromechanical machines, and greatly reduces maintenance—the system periodically checks itself and identifies the location and nature of faults. On-site repair consists chiefly of pulling out and replacing defective circuit cards. The printed circuit card may be returned to its manufacturer for rebuilding, or thrown away.

Automatic long-distance dialing is being extended. About 60 percent of all long-distance calls in 1964 were dialed and automatically

Defective circuit card is replaced in telephone electronics central office after being located by computer.

billed; this proportion is expected to rise to 80 percent by 1970, 90 percent by 1975. New Traffic Service Position (TSP) equipment automatically switches person-to-person, collect, credit card, paystation, and other special service calls with only momentary operator intervention. By 1970, it is expected that TSP's will be installed throughout the Bell System, eliminating virtually all manual switchboards. By the early 1970's, also, it may be possible to dial nearly everywhere in the world (operator overseas dialing is growing rapidly at present).

Placing and maintenance of cable and wire are being simplified. By burying cable and wire in new housing developments before landscaping, and by prewiring houses, office buildings, and apartments during construction, subsequent telephone installation is simplified. Wires are being permanently assigned ("dedicated") from the central office to an address, eliminating rearrangement each time service is disconnected and a new customer moves in; simplifying the training of new engineering personnel; and reducing engineering, installation, and reconnect costs. Placing cables under air or gas pressure (which both protects the cable from water damage and expedites location of leaks), and use of plastic insulation, simplified splices, and connections, greatly cut maintenance time and skill required.

Computers are extensively used. There are over 400 computers in the Bell System alone. Applications cover a variety of functions: e.g., customer billing, traffic and plant planning, equipment ordering, inventory control, line assignment, directory composition, and directing the flow of traffic through long-distance networks. These functions affect professional and clerical employees.

An optical scanner is now used in a least one State to read all bill payments and feed data into a computer which automatically updates customer accounts. Computer searching as a substitute for manual directory searching by information operators is in trial stages (information calls represent 2.5 percent of all originating calls). Computer-directed semiautomatic answering of intercept calls (wrong number, changed number, etc., representing 1 percent of all originating calls) is already operating in one large city. After an operator "keys in" the called number, this system determines the reason for intercepting the number, "remembers" the proper answer to be given to the caller, then composes the answer from a recorded vocabulary and "responds" vocally to the caller. A fully automatic system is under development.

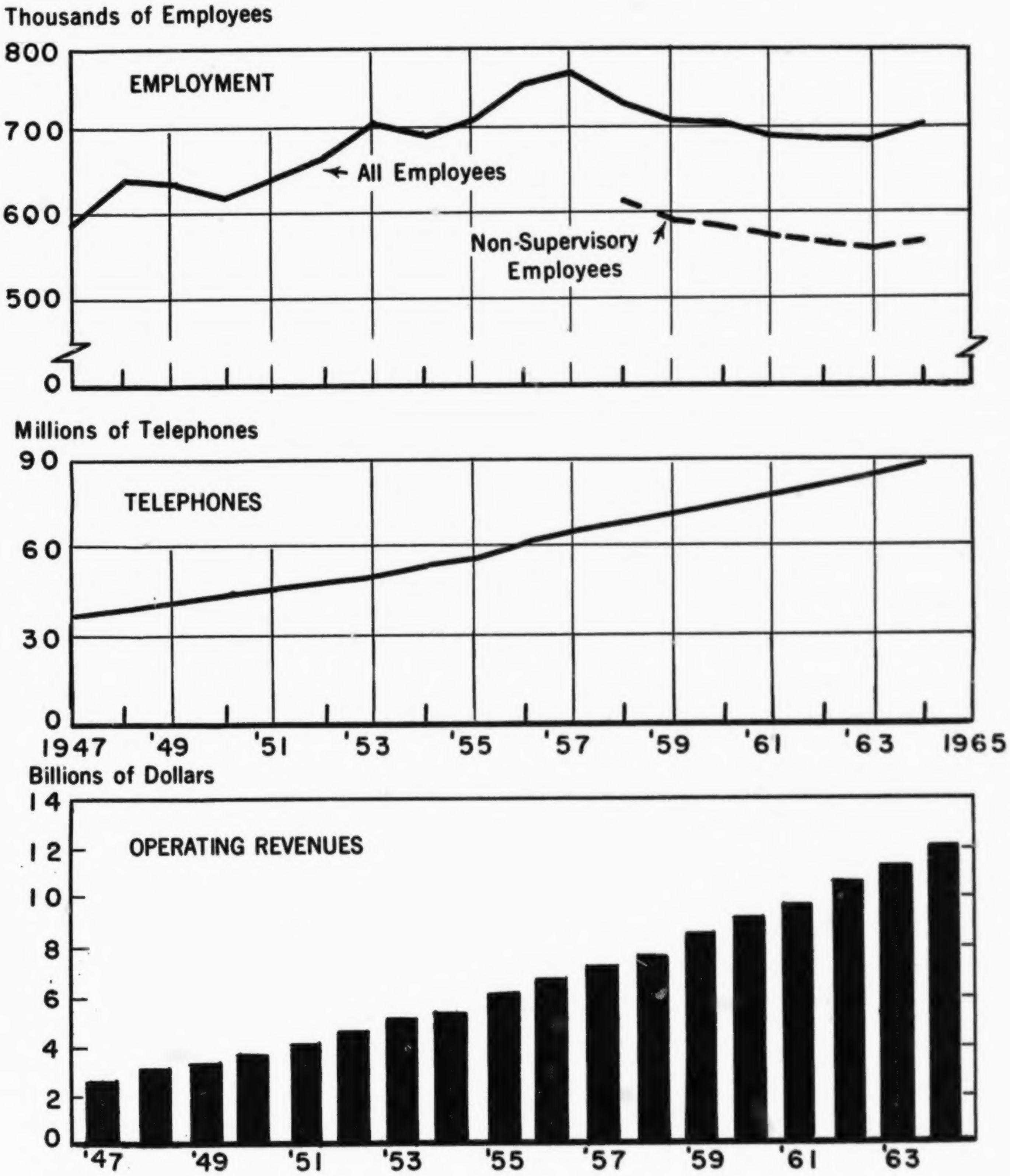
The fast pace of technological change is reflected in heavy outlays for new construction and research. Outlays for new plant and equipment in 1965 are estimated at about $4.5 billion, about 10 percent more than in 1964. The rapid technical advances in telephone communications are based on extensive basic and applied research in a wide variety of scientific fields.

Manpower Trends and Outlook

Employment is expected to remain fairly stable, or rise slightly, over the next 5 years. During the period 1947–57, total employment rose about 2.8 percent a year, from 585,500 to 768,200. Between 1957 and 1964, employment declined by 1.2 percent annually, to 706,100. Because of technological advances, about the same number of employees probably will be able to handle the greatly increased volume of service projected for 1970.

Occupational structure—altered in the past 15 years primarily by long-distance dialing—will undergo further change. Conversion from manual switching of long-distance calls to operator dialing, and then to customer dialing, has reduced the proportion of operators from 46 percent of all employees in 1947 to 27 percent in 1964. In Class A carriers, the number of operators fell 83,000, or 32 percent. Further laborsavings are expected when long-distance dialing is extended to person-to-person, collect, and other special service calls. Customer dialing of station-to-station calls reduced labor requirements for an identical mix of calls by an estimated 25 percent. An additional laborsaving of 25 to 30 percent is expected on special service calls handled through TSP. Automatic intercept, now being developed, could eventually eliminate virtually all intercept operators.

EMPLOYMENT , NUMBER OF TELEPHONES, AND OPERATING REVENUES IN TELEPHONE COMMUNICATION



Sources: Employment, Bureau of Labor Statistics; telephones and revenues, U.S. Independent Telephone Association.

Average annual percent change	
All employees	
1947–57	2.8
1957–64	–1.2
Nonsupervisory employees	
1958–64	–1.3
Number of telephones	
1947–57	6.2
1957–64	4.8
Operating revenues	
1947–57	11.1
1957–64	7.7

Clerical employment is being reduced. Despite expansion in business operations, nonsupervisory clerical employment has stabilized at about one-fifth of the total, but could decline as a result of extended use of computers. Plant clerks in line assignment groups will continue to be reduced by "dedicated" plant and computers. Some further reduction in accounting employees may take place as electronic data processing is extended; the impact has already been felt in processing of customer bills. Clerical sales jobs may increase.

Professional and semiprofessionnal employment will continue to grow. The group including engineers, programers, analysts, etc., increased from 5 percent of all employees in 1947 to 10 percent in 1964. Some technical employees who determine optimum traffic paths under varying conditions may be affected by the introduction of computer control of the long-distance network, now in pilot stages.

Construction, installation, and maintenance employees are becoming increasingly important. By 1970 this group may include 1 out of 3 telephone workers. The number of installers and repairmen is growing particularly rapidly despite laborsaving techniques enabling these employees to handle their fast-increasing workload more efficiently. Line and cable workers, however, are declining in number as mechanized equipment, such as ditch-diggers and pole placers, and self-supporting cable, eliminates the heavy labor which required large crews. With heavily equipped trucks, line construction crews have been reduced from four or five men in 1955 to two, with several trucks under a single roving supervisor.

The skill level of some central office maintenance workers may be lowered in electronic central offices. Craftsmen who test and repair switching and transmission equipment increased from 5 percent of all employees in 1947 to 9 percent in 1964. However, highly skilled testing, fault-locating, and rewiring will decline in electronic central offices; lower skilled maintenance workers will become relatively more important.

Some occupations requiring advanced technical skill are evolving at the highest nonsupervisory levels. For example, the installation and maintenance of data communication stations, radiotelephone, microwave, and private networks require extensive advanced training (usually provided by the telephone companies); radio licenses in some cases; broad knowledge of the telephone system; and responsibility for expensive equipment and service maintenance.

Job combination is taking place. Widespread use of polyethylene insulated cable, which simplifies splicing, has already blurred the once-clear distinction between cable splicers' and linemen's duties. Long-distance dialing eliminated many specialized operator jobs, leaving the remainder to be consolidated into a single "operator" job with a wider variety of tasks to perform. Combination sales-engineering jobs are growing with the demand for complex business communications systems. In the future, a combination of sales, installation, and collection work may be handled by one coin service (paystation) man.

Some Issues and Examples of Adjustment

Labor displacement because of technological change is being minimized through advance planning. Changes are introduced gradually, locality by locality, with advance notice of several years often given. Since a large proportion of the groups affected have been women (operators and clerks) with relatively high turnover, it has hitherto been possible to make most adjustments in the work force by not filling vacancies. Part-time and temporary employees are hired during thé transition. Surplus employees are offered transfers to other offices. Movement is facilitated by the "portability," within the Bell System, of pension rights and such seniority rights as apply to length of vacation and sick leave. Seniority in choice of shifts and vacation dates, however, may be temporarily lost by transferred employees.

Telephone companies operate extensive training programs. Because of rapid technological change, a telephone worker may go through several courses of training and retraining during the course of his employment. New techniques of instruction are being introduced, such as programed courses in basic electricity, operator procedures and salesmanship. Taped training programs, simulating actual traffic, are built into the equipment for TSP operators.

Industry unions are seeking to upgrade pay structures to take account of the impact of technological change on jobs. A committee of the Communications Workers of America studying job structure in 1961, for example, concluded that operators are now required to exercise more judgment and handle a larger variety of calls. After surveying 1,000 plant and clerical employees, the committee reported that some plant jobs which deal with installation and maintenance of complex, modern equipment require a higher level of skill than formerly. The committee recommended the establishment of a series of technician job titles for which premium wage rates should be paid. It also found that some clerical jobs require more judgment, responsibility, or a broader knowledge of company facilities than formerly.

Unions are seeking to restrict contracting out of construction. A 1959 BLS study of subcontracting clauses indicated that 20 of the 79 major contracts in the industry, covering about a third of all workers under collective bargaining agreements, limited subcontracting to some extent. In one recent arbitration case, the union unsuccessfully contested a new company practice (in one area of the country) of contracting out the placing of cable and wires to employees of the building contractor, rather than having it done by telephone workers.

Selected References

Technological Change

"Gas Lenses Show Promise for Long Distance Laser Communication," *Bell Laboratories Record*, September 1964, pp. 294–295.

Goetschius, Herbert H. "Microwave Today and Tomorrow," *Bell Telephone Magazine*, Summer 1964, pp. 14–20.

Mallory, Frank. "Planning for Obsolescence, Part I: Service Offering from Tomorrow's Equipment," *Telephony*, Nov. 7, 1964, pp. 65–66 and 160–161.

McKenzie, Alexander A. "New Era in Telephony: Electronic Switching," *Electronics*, Oct. 19, 1964, pp. 71–86.

Trotter, Dr. Herbert. "Communications in the Space Age," *Telephony*, Nov. 3, 1962, pp. 36–38 and 162–163.

USITA Traffic Bulletin. "Information and Intercept Practices," *Telephony*, May 16, 1964, pp. 35–37, 40.

Selected References—Continued

Manpower Trends and Adjustments

Automation, Impact and Implications, prepared by the Diebold Group, Inc., for the Communications Workers of America, AFL–CIO, April, 1965.

Beirne, Joseph A. *The Job Revolution in Telephones,* Communications Workers of America, AFL–CIO Education Department, 1959.

Industrial Retraining Programs for Technological Change, (BLS Bulletin 1368, 1963), pp. 25–31.

Lovitt, B. J. "Selecting and Developing Plant Men for the Future," *Telephony,* Nov. 7, 1964, pp. 80–81, 166.

Statement of Paul A. Gorman, Executive Vice President, American Telephone and Telegraph Company, in *New Views on Automation,* Papers submitted to the Subcommittee on Automation and Energy Resources, Joint Economic Committee, U.S. Congress, 1960.

Women Telephone Workers and Changing Technology, Women's Bureau (Bulletin 286), 1963.

The Electric Power and Gas Industry (SIC 491, 492, and 493)

Summary of Outlook Through 1970

Output is expected to continue rising at about the substantial rate of recent years. The high annual rate of growth in output per man-hour is expected to be maintained. Significant advances in technology are occurring in the integration and pooling of facilities using new transmission techniques, in steam-electric generating plants, nuclear power, special-purpose generators, automatic and remote control equipment, construction and maintenance techniques, new methods of power generation, and in techniques of natural gas transmission, distribution, and storage.

Stability in employment appears probable. An increasing number of professional, technical, and other skilled occupations will be required as tasks increase in complexity. Contracting out of construction and maintenance work is increasing. Retraining programs, normal attrition, early retirement, severance pay, and job transfers are being used by many companies in adjusting to technological change.

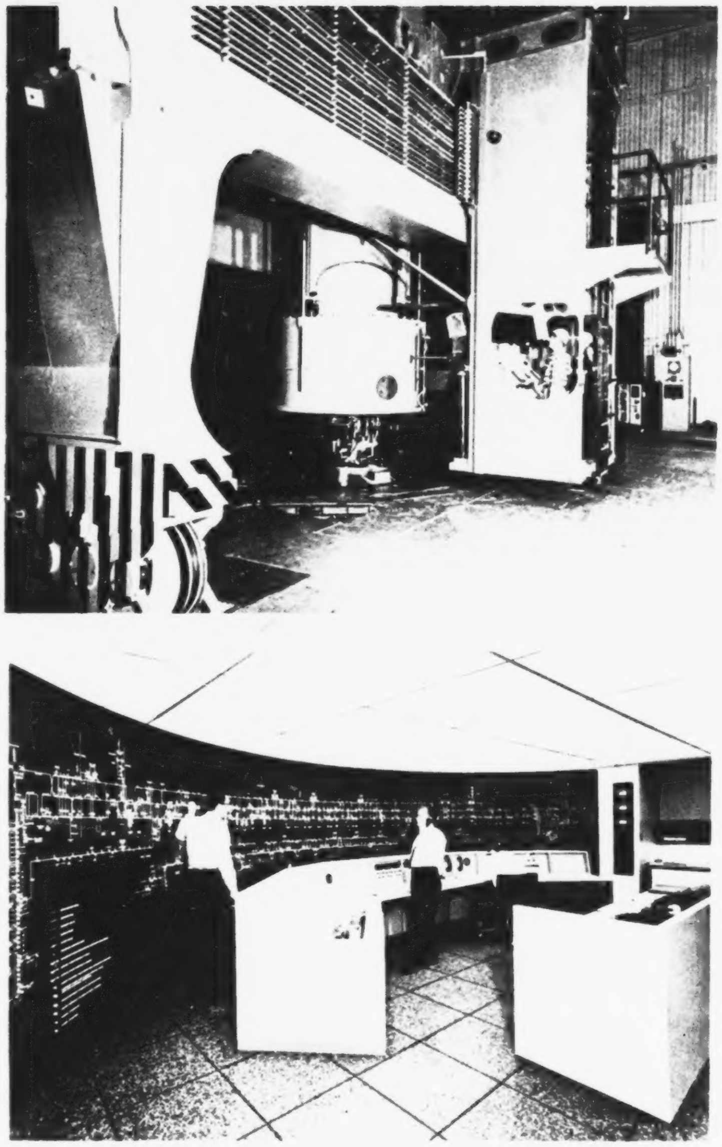
Outlook for Technology and Markets

Rapid growth in output is expected to continue. The combined output of electricity and gas (BLS composite weighted index) increased at an average annual rate of 9.5 percent in the period 1947–57, and 6.8 percent between 1957 and 1964. Net production of electric energy, doubling on the average every decade throughout the industry's 80-year history, grew at an average annual rate of 8.2 percent between 1947 and 1964. The National Power Survey (NPS) by the Federal Power Commission (FPC) estimates electric energy requirements will rise at an average rate of 6.8 percent annually between 1960 and 1980, reaching 2.8 billion mw.h. in 1980 (a megawatt—mw.—equals 1,000 kilowatts). Generating capacity has increased at 8.9 percent per year from 1947 to 1964. The FPC expects capacity will rise to 542.5 million kw. (including Canada, but excluding Alaska and Hawaii) by 1980, an average annual growth rate after 1960 of 7.6 percent. Production of natural gas (constituting over 98 percent of total gas output) rose 7.4 percent annually from 1947 to 1957 and from 1957 to 1964 has expanded at an annual rate of 4.7 percent. Output is expected by the NPS to average an increase of about 3.6 percent annually between 1960 and 1980.

New processes in industry, such as in iron and steelmaking, and increasing automation and mechanization are expanding the industrial uses of electric power and gas. More extensive use of air conditioning and heating equipment, including the heat pump and, recently, the heat bank device for storing heat, are increasing residential and commercial demand for electric power. About 2 million homes are now electrically heated, and the industry aims for 19 million by 1980. Research has been recently intensified toward development of an electric battery-powered automobile, potentially significant in counteracting air pollution, and estimated to have a market for electric power which could be large enough to double the industry's present sales.

Natural gas currently supplies about one-third of the energy requirement for homes, and approximately 26 percent of the fuels used by the electric utility industry. Total sales are about 117 billion therms, and consumption is expected to double in the next 20 years.

Process control computers are used increasingly in electric power and gas operations. The electric power industry, according to a survey by *Control Engineering* (March 1965), had 120 digital process control computers, compared with 80 in September 1963 and 17 in 1961. Gas utility and pipeline companies had eight digital process computers in dispatching and distributing. Of the 120 process control computers in electric power plants, 81 were in generating plants and 39 in dispatching operations. Computer advantages in data logging, scanning, alarming, and performance calculation tend to make them standard equipment in new and in many older large generating plants. Fuel savings, increased safety, better records, and improved manpower utilization are claimed. Some



(A) Fuel is loaded remotely into the reactor of a nuclear power plant. (B) Electronic equipment is used to coordinate operations of an entire gas pipeline system from a control center.

large plants have operations that are so complicated that safe operation requires a certain level of automatic control.

Most power plant process control computers are being used only for data processing, although control functions are possible and are utilized in a few installations. As of 1965, three installations have achieved full closed-loop control in which an operator is needed only for initial startup. Two separate computer systems installed in one plant in 1964 serve two separate generating units. These systems control initial startup operations including checking prestart conditions (performing prestart tests, boiler ignition and warmup, and synchronization), after which the unit is placed on economic dispatch control from the system's dispatching center.

Of the 39 process control computers used in dispatching in March 1965, 23 were being used for economic dispatch and automatic load control—operations principally concerned with dispatching power over transmission lines and coordination of generation and interchange. The computer control system provides an efficient means of regulating and controlling generation equipment to economically supply load at proper voltage and frequency. The benefits are direct dollar savings from instantaneous signals, optimization of power production, continuous generating unit control, and greater reliability and accuracy. Less paperwork, recordkeeping, and improved synchronization of loads between cooperating utilities afford indirect benefits.

One natural gas transmission company is using automatic controls extensively. The control of all gas flow and engines on the lines is exercised by the dispatcher on duty. Signals for suction and discharge pressures, gas flow, and engine speeds are transmitted over telephone circuits and are displayed on the panel board in front of the dispatcher. By pushing appropriate buttons on the control console, compressors can be started and stopped and pressures controlled. Other companies are studying the feasibility of remote control systems.

Remote controlled equipment is being used increasingly. Remote control devices are used in conjunction with electronic data processing in generating plants and dispatching operations of electric utility systems and in the operation of compressor stations of gas utility and pipeline systems. Signals for remote monitoring and control are carried by telemetry systems using carrier current, leased telephone lines and, more recently, by microwave. These systems enable utilities to operate, over large areas, even the most complex substations, with improved reliability, efficiency, and safety and with substantial savings in operating labor requirements.

Size of steam-electric generating plants continues to increase. Larger boilers and turbine generators, increased plant size, and greater use of outdoor construction, are sought because of resulting reductions in capital costs per kilowatt of installed capacity and lower operating, maintenance, and fuel costs per kilowatt hour of electricity generated. The largest generating unit in 1947 was about 208 mw.; in 1963, 650 mw.; and in 1965 a 1,000-mw. unit was installed. A 900 mw. unit is scheduled for operation in 1966, and one of 1,100 mw. is on order for 1969.

Special mechanized equipment is being introduced to handle the increasing amounts of coal needed in larger plants. In one installation, coal is sent through a breaker machine which produces pieces of uniform size and subsequently is handled by an automatic stacking-reclaiming machine. Two control centers—one at the car dumper house, the other in the plant's central control room—are used to operate the entire system.

Use of improved special-purpose generators is increasing. These generators, powered by gas turbines, jet and diesel engines, are being used increasingly to supply additional power during peak load periods and for insulated service areas. Such equipment is generally characterized by lower equipment and installation costs and lower labor requirements, but higher fuel costs.

Pumped storage plants also are being used to supply power during peak load periods. In pumped storage hydroelectric plants, electric energy, generated during nonpeak load periods, is used to pump water from a lower pool to a storage reservoir which is used in peak periods to generate power. At present, 32 pumped storage projects are in operation, under construction, or under active consideration, and an additional 69 sites have been identified as suitable for development. The estimated total capacity of all 101 sites is 36,000 mw.

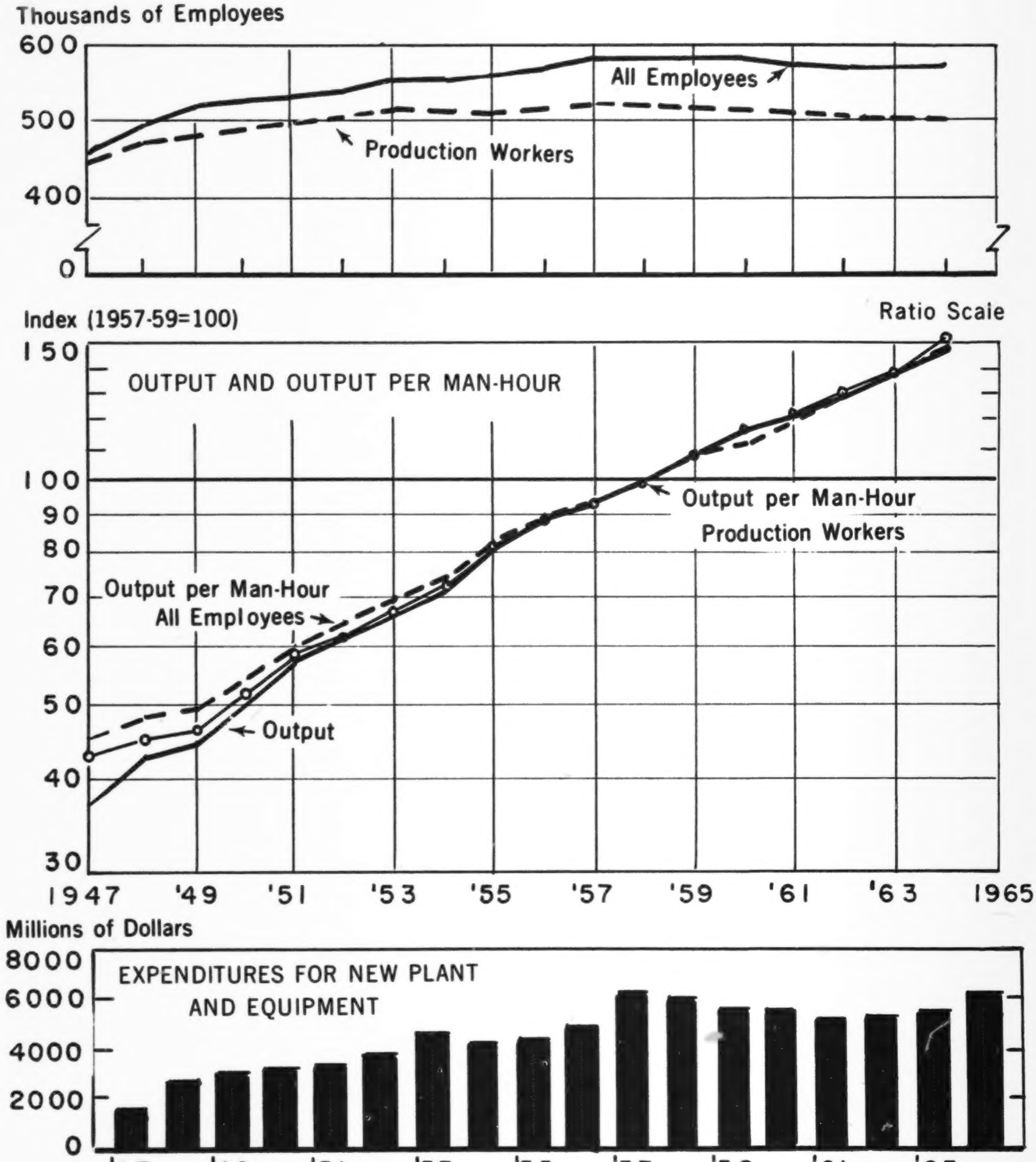
Small, prepackaged gas turbine generating plants, being introduced by the gas industry, produce electricity on-site to meet lighting and other demands for electricity in such commercial installations as apartment developments and shopping centers. By the close of 1964, there were about 200 so-called "total energy" installations in addition to a growing number of industrial gas turbine generators. Another possible independent source for residential use may be the natural gas fuel cell generator, which is in experimental operation.

Advances in extra high voltage (EHV) technology make transmission of large blocks of power more economical. Technological developments in capacitors, conductors, conductor hardware, transformers, and circuit breakers have facilitated the application of alternating current extra high voltage transmission (higher than 230 kilovolts—kv.). Benefits from larger generating units, coordinated pooling, exchange of power, selection of more favorable generating sites, and types of power supply are enhanced by the use of extra high voltage electrical transmission. Several experimental test installations are being used to resolve EHV problems for voltages as high as 750 kv. Since 1955, over 4,000 circuit miles of 345 kv. line have come into service, and additional lines are under construction. During 1965, some 500 kv. transmission facilities were energized and used to transmit power. About 5,000 miles of 500 kv. lines are planned for operation by the early 1970's.

Improved EHV technology now makes possible the transmission of large blocks of power over longer distances, thereby making more attractive the development of large, remotely located hydro resources and the development of mine-mouth plants (generating plants near coal and lignite mines) in many sections of the country. EHV transmission using direct current is also being constructed for economical long distance point-to-point transmission.

Expansion continues in the integration and pooling of power facilities. Increasing expenditures on coordination and integration are based on assured high rates of increase in demand, the economies of utilizing larger generating facilities and associated transmission equipment, and the sharing of benefits due to diversities of loads and resources. One major regional intertie between the Pacific Northwest and the Southwest is currently being conducted by several utilities, public and private. The FPC in its National Power Survey suggested a possible pattern of transmission by 1980 which includes three major East–West EHV interties and

EMPLOYMENT, OUTPUT, OUTPUT PER MAN-HOUR, AND CAPITAL EXPENDITURES IN ELECTRIC POWER AND GAS



Sources: Employment, output, and output per man-hour, Bureau of Labor Statistics; expenditures, Securities and Exchange Commission.

another long-distance interconnection between the Northwest and Middle South, in lengths ranging up to nearly 2,000 miles.

Improvements in technology have facilitated expansion of transmission, distribution, and storage of natural gas. New compressor stations, powered by gas turbines, have simplicity of design which, by ease of maintenance and adaptability to automation and remote control, save maintenance and operating labor. Recently developed techniques have made available expanded facilities for underground storage pools for gas in depleted gas fields, salt formations, and mined caverns, helping to assure greater reliability, flexibility, and economy of supply. From 218,000 miles of natural gas pipeline in 1945, the mileage has grown to about 736,000 miles in 1964. Larger diameter pipe is being used, with one company having more than 11 miles of 42-inch diameter pipe in service.

Gas refrigeration (cryogenics) which reduces a large volume of gas to a small volume of liquid (600-to-1 reduction ratio at −259°F), makes gas storage more economical and provides a local supply from which gas utilities can meet peak demands. Shipment of liquefied gas by water, rail, or truck is now commercially feasible; shipments by sea from Mediterranean to West European ports are on a regular schedule. Cryogenics may play a large role in the desalting of sea water by a vacuum-freezing vapor-compression process in which vaporized gas or boil-off gas is used to refrigerate the salt water to form ice.

Contracting out of construction and maintenance (with associated employment) to firms outside the electric and gas utilities is increasing. Greater construction volume and larger, more complicated plant and equipment are encouraging contract construction of structural items including all foundation work, and especially construction of nuclear power plants.

Central maintenance (in which electric power companies provide roving crews for their routine plant-to-plant maintenance) is a growing practice. Contracting for highly specialized maintenance supervision also is increasing.

With the continuing search for gas reserves, highly specialized contractors are increasingly required to drill wells to 20,000 feet or more in depths up to 600 feet of water at considerable distances offshore, and to install pipeline systems to bring gas to shore stations.

Construction and maintenance techniques are undergoing change. Some of the innovations in transmission system construction and maintenance include use of the helicopter, the aerial lift, chemical weed control for maintaining rights of way, use of lighter metals for structures and conductors, and the barehand method (in which the workman handling the energized line becomes part of the circuit, with precautions against grounding such as working in fiberglass buckets, and avoiding any other conductor). These improvements have resulted in reductions in work crew size, faster construction and maintenance schedules, and changes in work rules and practices. Using a helicopter to carry men, materials, and even assembled structures, one utility reduced overall construction time of transmission lines by one-half. In one company's practice, use of the barehand method with an aerial lift required about one-tenth of the labor for conductor repair and about one-fourth for insulator replacement compared to conventional methods; the estimated annual savings from barehand maintenance was about $46,000 compared with the $30,000 purchase price of the aerial lift.

Underground residential distribution (URD) systems are being encouraged by greater concern with beauty of landscape and by economies in improved materials and installation techniques (especially the use of aluminum in place of copper conductors), reducing the costs of placing distribution circuits underground. Safety is increased for both utilities and the public. Elimination of need for tree trimming and of failure of overhead facilities as caused by ice storms and hurricanes are significant economic advantages. Tax benefits and Federal grants for research on better, less expensive ways to place lines underground have been suggested. There were about 250,000 single-family dwelling units connected to URD systems in the United States in 1965; by 1970, the number may be five times greater.

Expenditures for new plant and equipment have been rising steadily. According to *Electrical World*, capital expenditures for the electric utility industry amounted to $4.8 billion in 1964 and are expected to be $5.5 billion in 1968. According to the American Gas Association (AGA), new gas utility and pipeline construction expenditures were $1.7 billion in 1964 and are forecast to amount to $1.8 billion in 1968.

Research and development activities are increasing. R&D expenditures by the private electric utility industry and its suppliers amounted to about $152.7 million in 1964, according to the Edison Electric Institute. Of this total, about $46.1 million was spent by the major electric utilities and $1.1 million by the Edison Electric Institute; the major electrical equipment manufacturers spent $105.5 million on the development of electric utility equipment, 8 percent above the $97.6 million spent in 1963. Engineering application of computers, extra high voltage transmission, magnetohydrodynamics (MHD), use of nuclear power for desalinization, and electric heating are examples of important R&D projects.

Through 1965, approximately $1.5 billion has been spent on nuclear power development by the Atomic Energy Commission (AEC), and an additional $800 million by the utilities and major reactor manufacturers. The AEC is now expending $100–$150 million annually, compared with $50 million by private industry, and these rates are expected to continue.

Total R&D expenditures in the gas industry by utilities, transmission companies, equipment manufacturers and the AGA are estimated at about $20 million for 1964. A prototype natural gas fuel cell battery capable of delivering 25 watts at 6 volts has been developed by the Institute of Gas Technology, leading to the possibility of producing up to 20 kw.h. from a therm of natural gas. Project Gasbuggy, a joint venture of a gas company, the AEC and the Department of the Interior, is designed to explore the feasibility of using nuclear explosions to fracture low permeable gas reservoirs. If this project is successful, reservoirs now considered unproductive could become commercially useful, thereby increasing gas reserves.

Nuclear electric power development is being accelerated by government agencies, private electrical equipment manufacturers, and electric utilities. A total of 17 nuclear power plants, with 1,160 mw. capacity (total U.S. capacity in 1964 was 239,800 mw.), were in operation in 1964, some on an experimental basis. Of nine new nuclear plants either under construction or planned for operation by 1968, six will have a capacity of 400 mw. or more each. By 1980, as much as one-tenth of this country's capacity may be supplied by nuclear energy, according to FPC projections. The AEC expects that by the year 2000, all new steam-electric generating plants will be operating on nuclear fuel.

An important factor in the growth of nuclear power will be the development of technology for reliable and commercially feasible breeder reactor systems (which produce more fissionable fuel than they consume). The successful commercial operation of the breeder reactor would free nuclear plants from dependence on the limited supply of uranium 235. In the process of generating electrical power, the breeder reactor would convert U-238 or thorium to fissionable fuel, some of which would be consumed in place. The remainder of the converted materials could be reprocessed to provide fissionable fuel for the same reactor, or to fuel other reactors.

Prior to breeder reactors, the advanced reactors which are now in the prototype stage of development are expected to relieve the dependence on limited resources of low cost U-235 by reducing the requirement for U-235, and by permitting the use of natural uranium while still producing low cost energy. In addition, these advanced converter reactors allow the timely introduction of advancing technology to the growing nuclear complex. These reactors should be available for commercial service in the mid-1970's and the breeders sometime later.

According to the AEC, present types of nuclear power plants (i.e., water-moderated and water-cooled reactors) could be economically feasible under any of three conditions: if located in medium to high cost fuel areas; if plants constructed have large capacities; and if operation is at a high annual capacity factor.

One large plant (515 mw.) now under construction (estimated completion date, 1968) at Oyster Creek, N. J., a medium fuel cost area, may be the first, nuclear-fueled, commercially competitive steam-generating power plant in the United States. The U.S. Department of Interior, in cooperation with the AEC, is examining the possibility of obtaining low-cost water by combining large capacity power production and large-scale water desalinization. Densely populated areas such as Los Angeles and New York can use sufficient water and electricity to support economical operation of such dual-purpose nuclear power plants.

The operation of nuclear reactors requires extensive safety arrangements. Safety reactor features being developed include special instrumentation and monitoring, multiple auxiliaries to reduce risks of equipment and operation failures, and shielding and containment structures to contain any accidental release of radiation. In addition, special consideration is given to the location of plants to further minimize the hazard from any accidental release or explosion. Since 1961, the AEC's reactor R&D program has included a wide range of engineering tests and evaluation studies on safety of reactors.

More efficient methods for the processing, storage, and disposal of radioactive materials are under development, according to the AEC. The problems of designing a successful disposal system for nuclear waste have not yet been an obstacle to the development of the industry, but are becoming more acute.

New methods for producing electricity without the conventional generator are being actively investigated both in governmental and private laboratories. Magnetohydrodynamics (MHD), in which a jet of ionized gas or liquid metal vapor is forced through a magnetic field to produce electricity, with the gas or vapor replacing the armature of the conventional generator, shows the most promise for commercial application. Despite materials problems because of high temperatures (5,000°F) required to attain electrical conductivity in the gas stream, MHD appears to have the potential for becoming a bulk power generator with great savings possible when used in combination with a conventional steam plant. Recent progress in MHD technology has made feasible the construction of an experimental MHD plant, successful operation of which could lead to commercial development.

The problem of plasma (heat) containment in controlled thermonuclear fusion reaction (in which very light elements are made to collide, forming heavier elements, and releasing energy in the process) makes hazardous any forecast for power generation from this source for the immediate future. However, the enormous and virtually inexhaustible energy potential means that work on harnessing this source of power undoubtedly will continue.

Other approaches: thermionic generators, thermoelectric generators, fuel cells, and solar cells require no moving parts, and may be able to operate long periods without maintenance, but have the common disadvantage of producing direct current in small quantity at very low voltage, in the order of one volt. Small size and potential efficiency make these generators useful in space technology and as a power source in remote areas.

Manpower Trends and Adjustments

Output per man-hour probably will continue to increase at the industry's historically high rate —about 7 percent annually. Output per all employee man-hour (combined private electric and gas utilities) rose at an average annual rate of 7.4 percent from 1947 to 1957, while output per production worker man-hour rose about 8 percent annually. Between 1957 and 1964, output per man-hour increased 6.9 percent annually for all employees and 7.4 percent for production workers. Continued high rates of productivity increase are anticipated due to rising sales of gas and electricity and the impact of technological innovations.

Stability in employment appears probable. Total employment, which amounted to 469,500 in 1947, rose to 581,800 in 1957 and declined to 575,900 in 1964. Production worker employment which rose from 446,400 in 1947 to 523,300 in 1957, declined to 501,400 in 1964. The proportion of production workers was 95 percent of total employment in 1947, and 87 percent in 1964. Reduction in unit labor require-

Average annual percent change	
All employees	
1947–57	2.2
1957–64	– .1
Nonsupervisory	
1947–57	1.6
1957–64	– .6
Output	
1947–57	9.5
1957–64	6.8
Output per all-employee man-hour	
1947–57	7.4
1957–64	6.9
Output per nonsupervisory worker man-hour	
1947–57	8.0
1957–64	7.4

ments is expected to be offset by increases in total output and expansion of service to new consumer areas. (Employees in government-owned utilities are not included in these figures.)

A more skilled work force will be required. The proportion of professional, technical, craftsmen, foremen, and kindred workers is now about one-half of total employment and is expected to increase through 1970 and 1975. The proportion of operatives and kindred workers, which has been declining, is expected to decline even more through 1975 as a result of the use of central control rooms and larger generating units.

The ratio of clerical and kindred workers, 23.4 percent of all employment in 1960, is expected to decline through 1970 and 1975, mainly because routine clerical work is being handled increasingly by computers. Meter readers, a major occupational group, could be virtually eliminated if an automatic meter reading system is successfully developed.

Nature of operator's job is undergoing change. Advances in process automation are making possible the consolidation of previously separate jobs, diminishing the number of plant operations required, but adding to the complexity of the operator's duties and responsibilities. At one steam-electric plant, only a single operator per shift is required. Working from a central control room, the operator uses integrated automatic devices, automatic remote controls, and closed circuit television for the entire startup and shutdown operations, displacing substation, switchboard, and generator operators. However, only a few such plants are expected to be operating by 1970.

Older workers, being generally associated with the operation of older plants, especially are affected by generating plant modernization. Older plants, so long as they are operable, are usually placed on a standby basis to meet seasonal peaks, but shutdown through forced obsolescence is increasing as a greater range of special-purpose generators becomes available.

Provisions in a number of collective bargaining agreements are concerned with contracting out of work and separation of workers. The reduction of seasonal peak and valley in demand for electricity, with fewer employees from the winter's peak available for summer maintenance and construction work, is stimulating the trend towards contracting out in these occupations. Of 78 major collective bargaining agreements in the gas and electric utility industry (1959), 44 contained provisions regarding the use of subcontracting. Of 86 major agreements (1963), 21, covering 50,000 workers, provided severance pay and layoff benefit plans.

Government programs have trained thousands of people in nuclear power technology. AEC special fellowships provide for graduate study in nuclear science and engineering, health, physics, industrial hygiene, and industrial medicine. The Argonne Institute of Nuclear Science and Engineering in Illinois, the Oak Ridge School of Reactor Technology, and the Oak Ridge Institute of Nuclear Studies in Tennessee, have offered courses to AEC contractor employees, private industry personnel, and college students and faculty. The International Brotherhood of Electrical Workers, since 1959, has provided training in industrial atomic energy uses, hazards, and controls to its members.

Major technological changes usually are effected slowly, thus facilitating adjustments. Most changes effecting substantial reductions in employment opportunities require a fairly long period for installation or conversion. One large utility took 5 years for conversion to natural gas; substation automation in the same utility, 15 years. The introduction of electronic data processing, which has a significant impact on office employment, is usually accomplished over a 3- to 5-year period, depending on the size of the system. It is customary for electric and gas utilities to transfer redundant workers and effect permanent reductions in the work force through attrition without forced layoff or retirement.

Selected References

Barthold, L. O. and H. G. Pfeiffer. "High Voltage Power Transmission," *Scientific American*, May 1964, pp. 38–47.

Drewry, F. S. and J. R. Howard. "Taking The Giant Step in Power Plant Automation," *Instrument Society of America Journal*, July 1964, p. 53.

National Power Survey, Vol. I and II. Federal Power Commission, 1964.

Civilian Nuclear Power. U.S. Atomic Energy Commission, March 1962.

"Process Computer Scorecard Updated," *Control Engineering*, March 1965, pp. 57–62.

Estimated Growth of Civilian Nuclear Power. U.S. Atomic Energy Commission, March 1965.

The Nuclear Industry, 1965. U.S. Atomic Energy Commission, October 1965.

Program for Advancing Desalting Technology. U.S. Department of the Interior, September 1964.

The Outlook For Central-Station Nuclear Power in the U.S., Arthur D. Little, Inc., Cambridge, Mass., September 1964.

Fundamental Nuclear Energy Research. U.S. Atomic Energy Commission, December 1963.

Seaborg, G. T. "Nuclear Power Comes of Age" (Remarks before the Annual Convention, Edison Electric Institute, May 4, 1965). U.S. Atomic Energy Commission release, May 4, 1965.

Sporn, P. "A Post-Oyster Creek Evaluation of the Current Status of Nuclear Electric Generation," in *Nuclear Power Economics—Analysis and Comments—1964*, Joint Committee on Atomic Energy Print, 88th Cong., 2nd sess., October 1964.

Indexes of Output Per Man-Hour: Gas and Electric Utilities Industry, 1932–62. U.S. Department of Labor, Bureau of Labor Statistics, 1964.

Manpower Planning to Adapt to New Technology at an Electric and Gas Utility: A Case Study (BLS Report 293, April 1965). 30 pp.

"The 1965 Utilities Conferences," *Electrical Worker Journal*, May 1965.

The Wholesale and Retail Trade Industry (SIC 50, 52-59)

Summary of Outlook Through 1970

Growth in trade volume through 1970 is expected to rise at higher rates than in 1960–63, as population and disposable income increase. Improvements in materials handling, new packaging techniques, and more extensive use of computers for data processing, particularly in large stores and warehouses, are among the major changes underway. However, smaller firms and many areas of trade are relatively unaffected by these changing technologies. Further diffusion of vending machines and other types of self-service merchandising is also taking place. Employment will continue to increase at the same high rate as in the past 4 years, despite increasing reductions in unit labor requirements resulting from technological advances in a number of trade sectors. A large part of the increase in retail employment is expected to be among part-time workers, including many women and young workers.

Outlook for Technology and Markets

Trade volume is expected to rise considerably. Volume of trade, measured in terms of gross national product originating in wholesale and retail trade (in constant dollars), rose at an annual rate of 2.9 percent from 1957 to 1963. This was slightly lower than the rate of increase of 3 percent in the previous 10-year period, 1947–57. A more rapid period of growth occurred from 1960 to 1963, when the annual rate was 3.5 percent. Volume of trade from 1963 to 1970 could grow at about 4–4.5 percent annually according to some industry experts.

Extension of prepackaging to many lines of retail trade can be expected in the next 5 years. Prepackaging by manufacturer or wholesaler reduces retailers' handling costs, improves stock control, and minimizes in-store inventory. In addition, easily identifiable prepackaged items allow self-service selling, reducing sales personnel. Some nondurable items (e.g., men's shirts, sheets, underwear), previously repacked three or more times as they moved from factory to consumer, are now arriving at the retail store attractively prepackaged and ready for the shelf.

Centralized prepackaging of perishable food items by retail chains for distribution to individual stores is, at present, the most widespread application of prepackaging. Several recent studies by the U.S. Department of Agriculture on centralized processing and packaging of meat and cheese indicate considerable savings in man-hours over conventional retail store back-room processing. It is generally expected that centralized packaging will reduce packaging by individual stores of most meat and produce sold by food chains in the next 5 to 10 years.

New developments in packaging machines, wrapping, and auxiliary equipment for food prepackaging are reducing costs. This equipment is being used increasingly in food stores to reduce back-room man-hour requirements on meat, dairy, and produce. Many of these developments can also be combined with advanced materials-handling equipment, permitting flow-line production for volume prepackaging. For example, one wholesale produce packing company integrated an automatic produce feeder, tray feeder, shrink-film tunnel type of packaging machine, and automatic labeler into one production line, reducing packaging man-hours by 15 percent. In addition to reducing directly unit man-hours in wholesale trade, cheaper, more efficient developments in packaging also tend to reduce retail man-hours per unit by making more economical the further extension of prepackaging and self-servicing.

Computers are expected to be more widely used for a variety of complex data-processing functions. At the present time, about 500 computers are being used in approximately 300 of the largest retail firms throughout the country. By 1970–75, some industry experts expect the number of retail firms using computers to triple. Computer use in wholesale trade is probably more extensive, but also limited to the largest firms. As lower cost computer models become available, and more flexible computer programs are devised for use by data-processing centers, the smaller firms will probably be able to take advantage of some aspects of computerization.

Retail and wholesale use of computers is being extended from accounting and billing functions to more efficient inventory control, sales forecasting, work scheduling, and development and measurement of merchandising and promotion techniques. In wholesale trade, use of computers for better utilization of warehouse space and materials-handling equipment is of particular importance. In addition to providing management with a wide variety of pertinent information each day (previously too costly or time consuming to prepare), enabling closer management control, unit man-hour requirements in affected operations are generally lower. For example, since the introduction of computers about 8 years ago, one large department store has more than doubled its volume of sales, while the size of its clerical staff has been reduced.

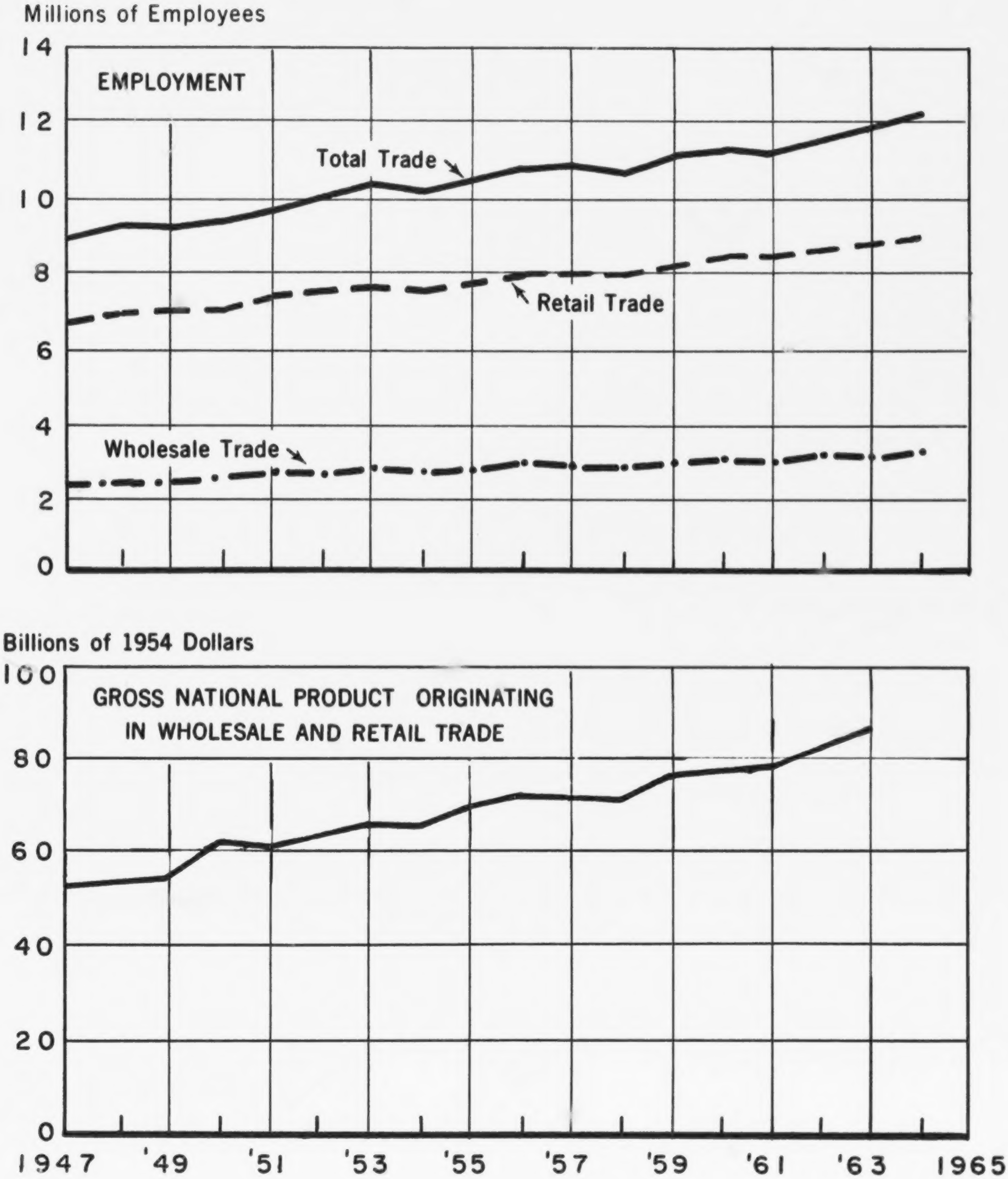
New data-processing input equipment increases computer potential. One major development rapidly gaining acceptance in large retail chain stores is the optical tape register. This manually operated register records details of transactions directly onto a tape which is later optically scanned for computer input. It not only reduces man-hours of work by dispensing with the need for manual tallying or card punching but provides considerably more information previously too costly to collect. Management can be provided with daily reports on sales, or stock turnover, subdivided by department or item for rapid analysis. These registers can be used by both large and small companies since smaller firms, which usually do not have computers, can utilize data-processing centers to process optical tapes. At the present time, there are about 12,000 optical tape registers being used in about 250 retail companies throughout the country.

Still in the developmental stage is an automatic check-out register for use in supermarkets. An optical scanner automatically reads codes on purchased items which the register translates into prices and automatically totals. It also produces information that can be readily processed by computers. Although this device may be twice as fast as conventional registers, reading and recording of merchandise is only a small part of the overall check-out job. Its adoption may, therefore, be limited until automatic bagging becomes practical, an operation which takes up the major portion of the time required for overall checkout.

Data-transmission systems are resulting in more efficient managerial control. An important development in large multistore retail organizations is the linking of the various stores to a central computer by telephone or telegraph wire, facilitating better control over customer credit accounts, and more rapid transmission of sales data for decisionmaking. A refinement which further increases credit control, and which has recently been installed in one large department store, is an automatic push-button telephone system enabling sales persons to communicate directly with the computer for immediate voice answerback credit authorization. Data-transmission systems also link a few wholesalers, and buying headquarters of chains, directly to suppliers, reducing paper work, order filling, and storage costs. Still new, diffusion of data-transmission systems, including automatic reordering, will increase as data-processing languages and equipment become more interchangeable. However, their use through 1970 will still be quite limited in number and to the largest retail and wholesale firms.

Improvements in materials-handling equipment and techniques are reducing unit labor requirements in warehousing. Fuller use of conveyorized materials-handling equipment in the moving of stock from truck to shelf is reducing labor requirements in large retail stores. More extensive use of palletization, powered conveyors, forklift trucks, and other mechanical materials-handling equipment will continue to reduce significantly manual handling in most wholesale and retail warehouses. In addition, some of the larger warehouses are introducing more automatic handling systems by integrating materials-handling equipment with various types of electronic controls and computers. One of the most advanced features of these systems

EMPLOYMENT AND GROSS NATIONAL PRODUCT IN WHOLESALE AND RETAIL TRADE



Sources: Employment, Bureau of Labor Statistics; gross national product, Department of Commerce.

is a punch card or tape-controlled order picker, which automatically selects items of an order, releases them from storage, and transports them by conveyor to a predetermined place for shipment.

Installation of these automatic systems is quite limited and will probably continue to be economically feasible only for fastmoving, volume items in large warehouses. Small volume items will continue to be picked manually, but will have all paperwork prepared by computers and will be transported by the electronically controlled conveying systems. An important advantage of these systems is that an increased volume at peak periods can be handled without requiring overtime of regular employees or supplementary part-time workers. For example, in one large frozen food wholesale warehouse, in which automatic order picking is utilized for 70 percent of daily case shipments, total daily man-hours were reduced by more than 50 percent and hourly case shipments increased fourfold by the use of the computer-integrated materials-handling system.

Self-service merchandising is moving into a number of retail trade areas. Self-service selling, requiring fewer unit man-hours of handling and selling than conventional operations, is already well established in supermarkets, drugstores, and the growing number of discount stores. It is also being introduced in department stores and variety stores, to reduce costs and compete effectively with discount stores. However, self-service in department stores will probably be limited because of their effort to maintain the benefits and appeal of personal selling and customer service.

Machine vending, requiring fewer man-hours per unit than conventional selling, continues to increase. Although vending sales increased by about 30 percent from 1961 to 1964, they accounted for less than 2 percent of total retail sales in 1964. Cigarettes, soft drinks, and confections (which comprised 40, 19, and 13 percent respectively of total vending sales in 1964) are expected to continue to be the major items sold through vending machines. According to some industry experts, by 1970, cigarettes sold through vending machines may account for 25 percent of total cigarette sales, compared to 16 percent in 1961. Sales of soft drinks, candy, and gum, which comprised 20 percent of total sales of these items in 1961, are expected to move up to 30 percent in 1970.

Prepared foods (hot canned foods, sandwiches, pastry, complete hot meals, etc.), accounting for about 5 percent of total vending sales in 1964, are expected to be the fastest growing area. New vending technologies, such as a microwave oven which heats frozen foods in seconds, are expected to open new markets, particularly in the area of institutional feeding (schools, hospitals, industrial plants, etc.).

Automated merchandising eliminates the need for sales personnel, but creates demand for workers to stock, repair, and service vending machines.

Manpower Trends and Adjustments

Employment will increase through 1970. Total retail and wholesale trade employment increased from 10.9 million in 1957 to 12.1 million in 1964, an average annual growth rate of 1.6 percent compared to a 2 percent rate between 1947 and 1957. From 1961 to 1964, the annual employment growth rate increased to 2.3 percent. As separate groups, retail employment (about 74 percent of total trade employment in 1964) and wholesale employment (with 26 percent of the total) increased at rates close to that of total trade employment during these periods.

Total trade employment will probably continue to rise through 1970, at about the high 1961–64 growth rate, despite reductions in unit man-hour requirements in a number of trade

	Average annual percent change
Total trade employment	
1947–57	2.0
1957–64	1.6
Retail trade employment	
1947–57	1.9
1957–64	1.7
Wholesale trade employment	
1947–57	2.1
1957–64	1.5
GNP originating in total trade	
1947–57	3.0
1957–63	2.9

sectors due to technological changes. Employment growth will result from the anticipated large increase in volume of trade, continued growth of branch stores, and the fact that recent technological changes are not expected to affect appreciably many areas of trade. In retail trade, for example, these include eating and drinking places and automotive dealers, which together comprise more than one-fourth of retail trade employment. Also, growth in employment in retail trade will reflect the increasing numbers of part-time workers, particularly women and younger workers.

Structural composition of the workforce will continue to change. The proportion of nonsupervisory workers to total employment comprised 90 percent in 1964 in retail trade (excluding eating and drinking places) and 85 percent in wholesale trade. Each of these proportions is slightly lower than in 1958. This trend will probably continue, and the rate of decline may accelerate.

Opportunities for sales personnel and materials handlers will continue to grow, although they may be slightly dampened by continuing introduction of laborsaving changes in merchandising and warehousing. As use of computers increases, demand for programers, systems analysts, engineers, and other various types of personnel trained in computer data processing will rise. The total number, however, will continue to be relatively small. On the other hand, more widespread use of computers and input equipment, such as the optical tape register, will result in a decline in the demand for clerical personnel, an occupational group that comprised about one-fifth of wholesale trade and one-eighth of retail trade employment in 1960.

Advanced planning and attrition in some instances have facilitated man-power adjustments to technological change. A 38-percent reduction in employment resulting from the installation of an automatic computer-integrated materials-handling system at one wholesale warehouse of consumer products, for example, was accomplished by means of attrition and without any layoffs. Similarly, another distributor of consumer products who introduced advanced materials-handling equipment avoided layoffs by transferring displaced employees to positions vacated by attrition in other departments.

Retraining is used as a method of adjustment to changing technology. A large department store, for example, has an agreement with the Retail, Wholesale, and Department Store Union to finance and operate a retraining program for employees whose jobs are eliminated by machines. Under provisions of the plan, an employee can train for a job equal to or lower in grade than the one from which he was displaced. The length of training equals the number of weeks of severance allowance the employee has earned. Executive training in some large retail firms is also receiving more widespread attention, partially because of changes in technology and operating methods.

Selected References

Technological Developments

"Automation of Tray Packaging," *Modern Packaging*, February 1965, pp. 111–113.

Bartz, Daniel J. "Computers: The Food Industry Challenge," *Progressive Grocer*, April 1965.

"Computers Begin to Solve the Marketing Puzzle," *Business Week*, Apr. 17, 1965, pp. 114–138.

Ewing, John S. and Murphy, James. "Impact of Automation on United States Retail Food Distribution," *Journal of Retailing*, Spring 1965, pp. 38–47.

"Report from Chicago," *Modern Packaging*, May 1965, pp. 147–154.

Schreiber, G. R. "1965 Census of the Industry," *Vend*, March 1965, pp. 32–61.

Taylor, J. L., Jr. "The Revolution in Retailing," *Credit and Financial Management*, December 1964, pp. 32–40.

U.S. Department of Agriculture, Agricultural Marketing Service, *Centralized Processing of Fresh Meat for Retail Stores*, October 1963, 76 pp.

Manpower Trends and Adjustments

Official Proceedings, 24th International Convention, Retail Clerks International Association, June 24–28, 1963, 456 pp.

Roberts, Richard S., Jr. *Management Decisions to Automate*, Stanford Research Institute, 1964, pp. 25–36.

The Banking Industry (SIC 60)

Summary of Outlook Through 1970

A wider variety and increased volume of banking services are expected to keep employment growing, despite extensive use of electronic data processing. Both large and small commercial banks are utilizing computers and magnetic ink character recognition equipment, and savings banks are starting computer accounting. Increasing use of data transmission facilities is foreseen.

The rapid rise in supervisory personnel should continue as banks establish more branches and develop new services. Strong demand for systems analysts, programers, and other computer personnel is expected to continue as automation is extended to more banks, while the demand for bookkeepers will be greatly diminished.

Outlook for Technology and Services

The banking sector will continue to expand as more emphasis is placed upon services. The number of demand deposit accounts is projected to increase at an average annual rate of 3.4 percent between 1965 and 1970, compared to 3 percent between 1960 and 1965. The rise is due, in part, to the increase in special checking accounts, requiring no minimum balance, which appeal to the small depositor. In addition, more widespread use is expected of such services as automatic deduction of insurance premiums from checking accounts, general collection of utility bills, and processing of charge account payments mailed directly to banks, saving days in crediting a firm's account. Other new or expanded bank services are wider application of installment credit, enlarged international banking departments, and a number of nonfinancial services for business firms, such as accumulation of marketing data.

While the number of banks has declined slightly, from 14,714 to 14,266, between 1947 and 1964, the number of banking offices has increased steadily, at an average annual rate of 2.6 percent, between these years. Since 1962, the number of banks, as well as branch offices, has increased.

By 1970 the great majority of large commercial banks will be using computers. Over 500 banks have either installed computers or have them on order. Most banks with at least $100 million in deposits now use computers, and almost all in this size group probably will be automated by 1970. In 1962, a Federal Reserve Board survey of banks having at least $25 million in deposits showed 344 of the 974 owning or renting computer systems. Several banks, primarily those with deposits of $100 million or more, have more than one computer. For example, one of the largest banks has nine computers run on a 24-hour day, 5½ days each week, by a staff of 739. In addition to processing checks, this system handles stock transfers, loans, investment studies, internal bookkeeping, and a check reconciliation service.

More than half the banks having $50 million to $99 million in deposits use computer facilities. The facilities are primarily purchased or rented, although some banks contract for computer services with a city correspondent bank or service bureau. It is estimated that 85 percent of these banks will process accounts by computer in 1970, and that a substantial number of smaller banks will have converted to computer systems.

Having discovered that their own paperwork often does not utilize all the computer time, some banks offer computer services to customers other than correspondent banks. The most popular are account reconciliation and payroll preparation which can be of advantage to all types of businesses. Billing services for doctors, florists, druggists, real estate firms, and other businesses have also been established.

Magnetic ink character recognition speeds check collection. The number of checks processed by the Federal Reserve System, approximately one-fourth of all checks handled by banks, increased by 72 percent between 1954 and 1964. To handle the ever-increasing volume, the industry, under the leadership of the American Bankers Association, sponsored the development of magnetic ink character recognition (MICR), a replacement for manual handling. Checks with stylized numbers printed in ink containing iron oxide can be read and sorted by a machine which magnetizes the ink. Certain areas along the bottom edge of checks have been designated for routing symbols, bank use (such as account number), and amount encoding. As the MICR reader-sorter sorts the checks, this information may be recorded on tape for computer processing. High speed sorters handle up to 1,680 items a minute.

The Federal Reserve System has encouraged banks to preprint routing symbols in magnetic ink, noting that even those banks without MICR reader-sorters benefit from faster check collection. In its February 1965 survey, the New York Federal Reserve Bank reported that 92.3 percent of the 16 million checks handled by the Federal Reserve System each day were preprinted, compared to 19.5 percent in February 1961. The Federal Reserve now urges that checks be amount encoded by the first bank to receive a check for collection.

Slow speed reader-sorters will replace manual handling of checks in the smaller bank. One manufacturer has introduced a slow speed reader-sorter, operating at one-third the rate of conventional MICR reader-sorters and selling for one-third the price of the high speed equipment. Banks with less than $50 million in deposits are likely customers for this equipment.

Electronic bookkeeping machines ('tronics) are replacing conventional posting machines—primarily in banks without computer facilities. Ledger cards used with 'tronics have strips of magnetic ink on the back which record the account number, balance, column and line selection, and check count. The bookkeeper updating an account keys the account number, which is verified by the machine, and if it matches the ledger card, the keyboard unlocks and the transaction is posted. The 'tronic picks up the old balance, adds or subtracts the new entry, computes the new balance, and enters it on the magnetic strips. A visible record is printed simultaneously on the front of the ledger. The only operations required of the bookkeeper are keying the account number and value of the transaction. Since a number is entered only once, errors are reduced, as is the time required for posting.

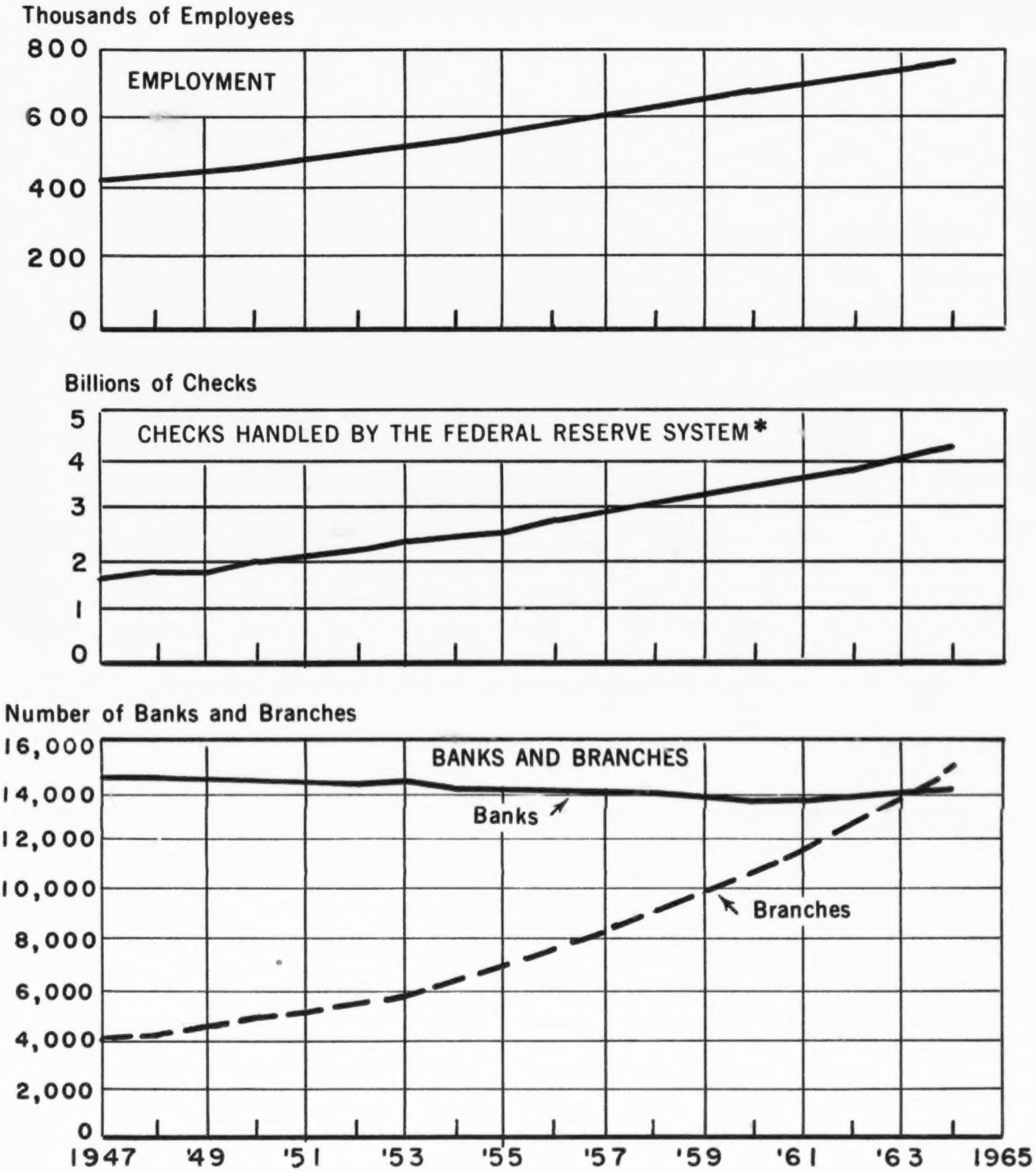
One industry expert estimates that at present about 3,000 banks have installed 'tronics. Small banks, particularly those with $25 million to $50 million in deposits, are the largest users of this equipment. Future use of 'tronics depends, to a great extent, on further development of computer centers and the rate of adoption of additional services necessitating the use of computers.

Savings accounts lag in computer applications. Many commercial banks regard automation of savings accounts as a low priority application. By the end of 1964, one-quarter of the banks using computers (including computer services) had automated their savings accounts; this was effected in less than 4 percent of all banks. To eliminate some of the paperwork from savings accounts, banks are adapting MICR to savings and introducing no-passbook savings. The latter, not yet legal in 15 States, facilitates deposits, but requires special handling for withdrawals.

Computer manufacturers are establishing on-line data processing centers for savings banks in metropolitan areas. The first center, scheduled to open in New York City this year, will serve eight savings banks and one savings and loan association. Participating banks must guarantee 500,000 savings accounts and 100,000 mortgage loans. The New York banks in the system are among the largest savings banks in the country. There are also a few individual banks with their own on-line computers. This facility enables any teller in any branch to handle any account transaction, as each window posting machine is linked to a central computer by leased telephone lines.

Closed circuit television is being applied in banking. The teller in a drive-up banking station is being replaced in some areas by two-way television and a system of pneumatic tubes. One industry expert estimates at present 200 units are installed. The teller remains in the bank, near the necessary records, and teller and customer see each other on television. Two drive-up stations may be handled by one teller during slack hours. Television is also one of several methods introduced for signature look-up.

EMPLOYMENT, NUMBER OF CHECKS HANDLED, AND BANKS IN BANKING



*Excludes U.S. Government checks

Sources: Employment, Bureau of Labor Statistics; checks handled and number of banks and branches, Federal Reserve Board.

Bank use of data-transmission equipment and machine-to-machine communication is expected to increase. At present, transmission networks are largely between banks, but the development of pushbutton telephones, introduced in 1963, will enable the telephone user to be connected with a bank's computer. Experiments are underway that will permit customers to pay bills by using the telephone keyboard. A computer will credit the store's account and debit the customer's, either refusing to process overdrafts or handling them through a prearranged line of credit.

Banks may soon clear large checks between cities by long distance reproduction, and by 1975, the cost of transmitting facsimiles may be lower than sending the documents themselves.

The feasibility of computers for on-line data processing of commercial and loan teller operations is being explored by several major banks, and computer processing may be extended to these areas within 5 years.

Manpower Trends and Adjustments

Employment is expected to continue to increase —but at a decreasing rate. Between 1957 and 1964, employment averaged a 3.4 percent increase annually, compared to an annual growth rate of 3.9 percent between 1947 and 1957. The trend to retail banking—services to the small depositor—has been largely responsible for the high rate of increase in employment, with automation tending to hold down employment in some areas while increasing the number of services provided by banks. A 3-percent annual growth in employment between 1964 and 1970 is forecast, increasing the number of bank workers from 764,400 to over 900,000.

Average annual percent change	
All employees	
1947–57	3.9
1957–64	3.4
Number of checks handled by the Federal Reserve System	
1947–57	6.0
1957–64	5.5
Number of banking offices	
Number of banks	
1947–57	–0.4
1957–64	0.2
Number of branches	
1947–57	7.0
1957–64	8.7

Bookkeepers are hardest hit by automation. Electronic bookkeeping machines require about one-half to two-thirds the personnel to do the same job as conventional bookkeeping machines do; computers can further reduce the need for bookkeepers. For example, at one multibranch bank, within 18 months after the start of conversion to electronic data processing (EDP), the bookkeeping staff of 600 had been reduced to 150, and the data processing staff had grown to 122, a net reduction of 55 percent. Very nearly all of the jobs eliminated were in branch offices, while most of those created were at the data center. Most banks experience a net reduction in force of 40 to 50 percent in affected operations.

Although on-line computer equipment may enable a teller to serve more customers, continued increase in the number of branch offices means that more tellers will be needed. Some of the decline in clerical employment is offset by the creation of new jobs, such as keypunch operators and MICR encoders.

The number of supervisory personnel has been growing. The significant increase in the number of bank branches—over 5,000 new offices in the past decade—has necessitated more bank officers, as has the growth of services to the small depositor. In one bank, for example, a 5-percent decline in total employment was accompanied by a corresponding 5-percent increase in the number of bank officials.

Introduction of automation has modified old jobs and created new ones. The operations officer, responsible for branch operations, no longer has much detail work to supervise, since bookkeeping has been removed from the branch offices. He is now expected to spend more time in the front office, handling customer relations. In other cases, automation may eliminate only part of a job, and in these instances part-time workers may perform the remaining tasks.

The principal new occupations are EDP equipment operator, programer, systems analyst, encoder, and EDP clerk. There is a strong demand for computer programers and systems analysts, and the need for such trained personnel is expected to increase as more banks automate.

While a high percentage of bank employees are women, their numbers have not increased as rapidly as total employment. Since 1960, the average annual rate of increase has been 3.0 percent for women, compared to 3.7 percent for men. Women, however, still comprise more than 60 percent of the banking labor force, and hold many jobs which are not significantly affected by automation, such as secretaries, typists, and tellers.

Heavy turnover of personnel in areas affected by computer operations enables automation to occur without layoffs. Since turnover among women clerical employees is relatively high and the length of time for computer installation is fairly long, natural attrition is often used to take care of labor displacements. For example, at one large statewide bank, having more than 150 branches, the decision to automate was spurred by the high turnover rate of bookkeepers. Requiring 2 months to train, the average bookkeeper left after 8 or 9 months.

Selected References

Technological Developments

Alson, Robert S., et al. *Automation in Banking.* New Brunswick, N.J., Rutgers University Press (1963).

The American Bankers Association, Department of Automation and Marketing Research. *Automation and the Small Bank,* New York, N.Y. (1964).

——. National Automation Conference. *Proceedings* (1963).

Bratter, Herbert. "Progress of Bank Automation," *Banking,* September 1962, p. 47.

Eckert, James B. and Wyand, Robert R., II. "Automation at Commercial Banks," *Federal Reserve Bulletin,* November 1962, p. 1408.

Feldman, John J. "Savings Automation in the Nation's Banks," *Banking,* February 1965, p. 109.

Reistad, Dale L. "The Impact of Automation on the Nation's Banks," *Banking,* October 1964, p. 51; November 1964, p. 106.

Manpower Trends and Adjustment

Stanford Research Institute, *Management Decisions to Automate,* Report prepared for Office of Manpower, Automation and Training, U.S. Department of Labor, 1964.

Wiener, Rose. "Changing Manpower Requirements in Banking," *Monthly Labor Review,* September 1962, pp. 989–995.

Insurance Carriers (SIC 63)

Summary of Outlook Through 1970

The number of insurance policies sold and the variety of services provided by insurance companies are expected to increase through the rest of the 1960's. All large- and medium-size insurance companies now are using electronic data-processing (EDP) equipment for office work. Within the next 5 years, many insurance companies will have developed their EDP applications to the point where all major insurance office functions will be performed through a computer system and numerous separate handlings consolidated into one EDP flow. The data transmission networks that are being installed between home and field offices by the larger carriers will result in less recordkeeping in field locations and in faster policyholder service.

Agents employed by carriers, employees in sales-related occupations, and professional employees are expected to increase. Clerical employees, however, probably will not increase in number, due to advances in electronic data-processing systems. The industry may no longer be a source of numerous opportunities at the entry level for female high school graduates.

Outlook for Technology and Markets

Insurance sales are expected to grow steadily through the next decade. The amount of life insurance in force increased 74 percent between 1957 and 1964. Ordinary life insurance, which accounts for nearly three-fifths of all insurance in force, increased about 72 percent between 1957 and 1964. Group insurance, which requires relatively less sales effort and now accounts for about a third of all life insurance in force, nearly doubled during this period. This was due primarily to the inclusion of life insurance in employee benefit programs. Credit life insurance, usually a form of group insurance, is the fastest growing form of policy, although it represents only 6 percent of all insurance in force.

Property and casualty insurance sales also are growing, particularly the "package" policies (e.g., homeowner's and commercial multiple-peril). New types of coverage are being offered to appeal to specialized markets such as hotels and motels. There also is a trend toward offering a variety of options that can be combined into packages tailor-made to customers' individual needs.

Health insurance sales are increasing as medical costs rise. Medicare, which will be administered partially by private insurance companies, probably will increase the processing work of some carriers, and also may stimulate new demand for supplementary health insurance.

Electronic data processing has been adopted throughout the industry. Over 80 percent of all insurance employees by 1963 worked in companies that had electronic computers. A BLS survey in 1963 found that since 1954 about 300 companies had acquired more than 800 computers. Usually, EDP equipment is centralized in the home office, but a few large, nationwide companies have smaller computers located in field and regional offices. Since 1960, companies have been exchanging their older vacuum-tube computers for faster and larger transistorized

Programer and console operator check computer print-outs.

models. Between 1965 and 1970, they will be installing "third generation" computers with very fast, random access memories.

Computer systems are being applied to a wide variety of office operations. Companies in the BLS survey were using EDP for 11 major functions, on the average. Most often, EDP is used for the high-volume tasks of premium billing and accounting, reserve and commission accounting, and for dividend accounting. Use of EDP for these operations is reported to permit expansion of business and of types of policies and options; improved policyholder service; closer management control over losses and sales agents; and more efficient organization within the company.

Consolidation of applications into an integrated EDP system is taking place. Before consolidation, many separate operating departments, each having only a part of the policy file, were required to handle a wide variety of insurance office functions from premium billing to loan accounting. As each function is programed for EDP, it becomes possible to handle more tasks through a single master policy record contained in the computer file. Separate records and tabulating units are eliminated, fewer controls and audits are required to keep all policy information in balance, and clerical posting jobs are greatly reduced.

Sixty-six of the companies covered by the BLS survey had consolidated EDP systems by 1963, although the fullest potential of consolidation had been reached in few of these offices. By 1970, consolidation of all major company operations within the EDP system probably will be completed in most companies having computers. Computer manufacturers have developed standard "consolidated functions" programs for the insurance industry, and these have been adopted by a number of medium-sized and small companies that recently installed computers. Larger companies will move more slowly in pulling major operations together, because of the extent and variety of their business.

Use of data transmission networks will grow rapidly. Data transmission by telephone or telegraph lines had been installed between home and field offices in 18 large companies included in the BLS survey; 29 other surveyed companies had plans to install such a system. The use of data transmission networks reduces the number of records kept in field offices, by providing for direct connections between field personnel and home office computer files. Consequently, policyholder service and premium collections are much more rapid. Information requests, claims processing, and premium payment information can be handled quickly, usually on an overnight batch basis.

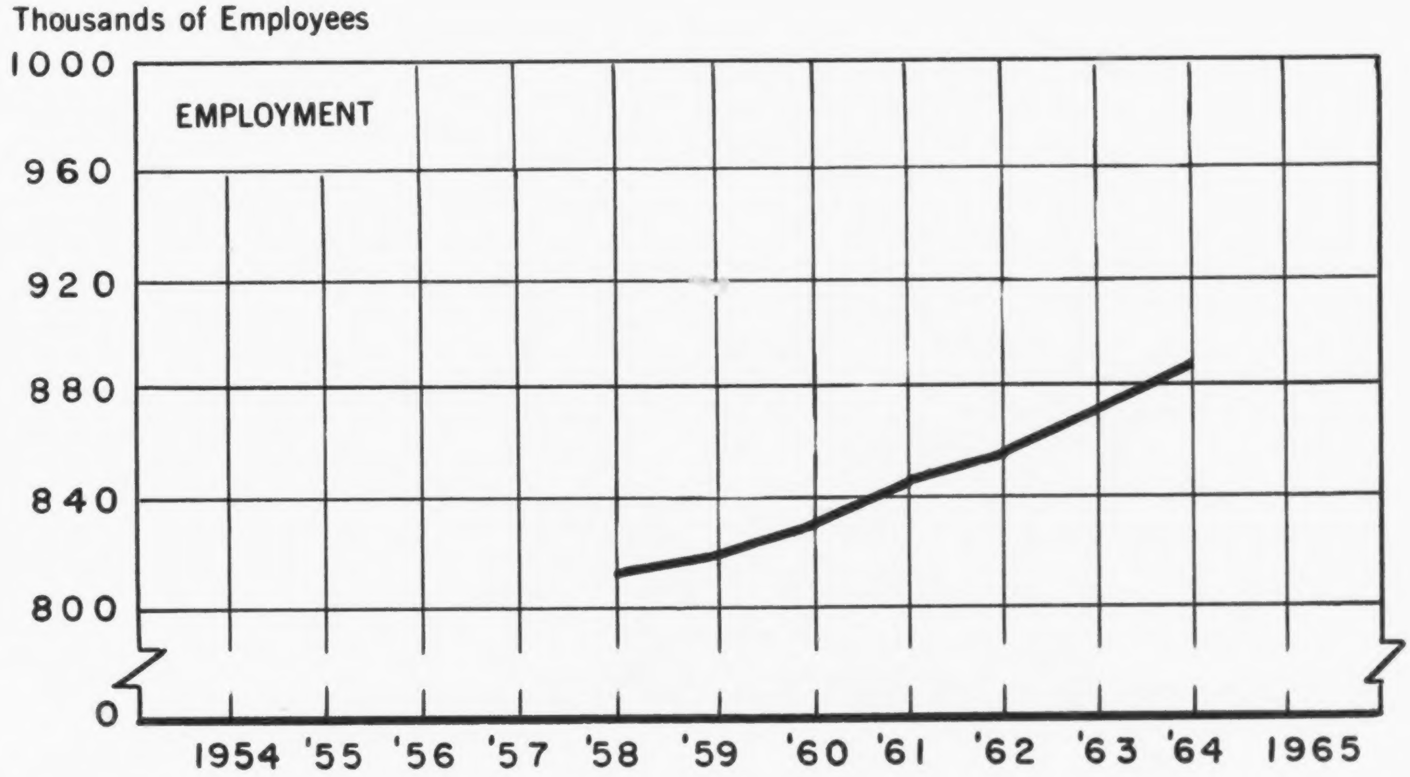
Within a few years, many major insurance carriers may link their computers and transmission networks into a "real time" system, in which each transaction is processed as it occurs. The home office computer will respond instantaneously to information requests and transaction orders from all field locations. Very small companies which do not install their own computers may, through the use of data transmission, begin to use service bureau computers on a time-sharing basis.

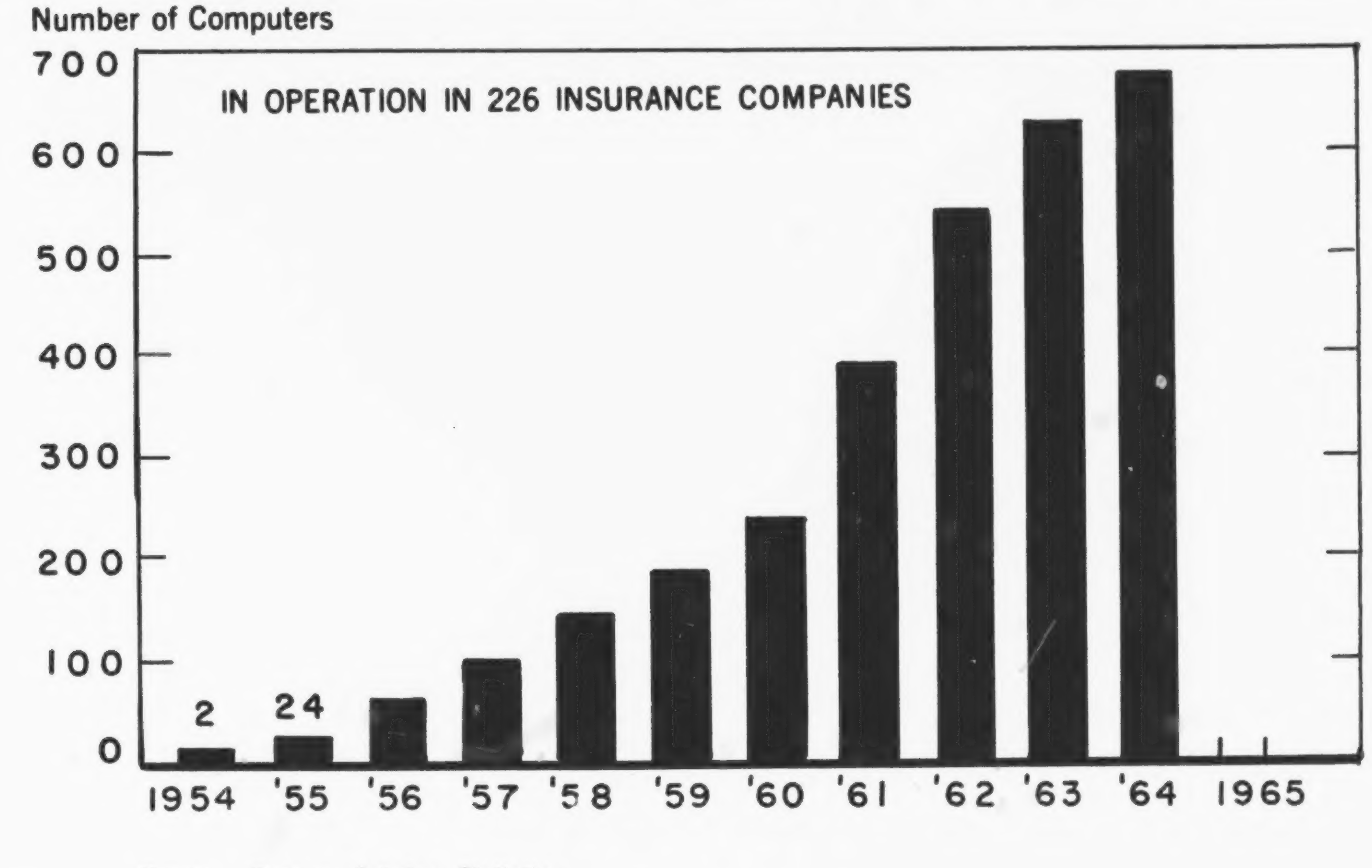
Optical scanners are being installed to reduce keypunching work. In most applications, the scanners are used to read premium payment information from bill stubs returned by the policyholder. The scanner produces computer-readable tape, from which the computer then updates policy records automatically. In the near future, optical scanners may be used to "read" office-originated forms for processing policy loans or surrenders, or customer-marked forms such as policy applications or change requests.

Mergers and new marketing techniques are altering industry organization. There is a continuing trend toward selling all lines of property, casualty, and even life insurance by one group of affiliated companies, or by merged property-casualty companies and a life affiliate. In this way, one sales organization can offer a full range of insurance services, and home office recordkeeping can be integrated and simplified.

Property and casualty carriers are changing to a direct billing system. Previously, agencies billed policyholders and then remitted premiums to the carriers. Direct billing from the

EMPLOYMENT AND NUMBER OF COMPUTERS IN THE INSURANCE INDUSTRY





Source: Bureau of Labor Statistics

carrier's home office eliminates some agency recordkeeping and reduces service costs per policy, by permitting computers in the carrier home office to take over the full range of premium billing and accounting activity. The change to direct billing also facilitates more consolidation of records through the EDP system.

Increased competition among companies is leading to new rating systems for automobile and other types of policies, and to new combinations of coverage in the total package. The growth of group insurance, direct sales appeals to customers through advertising, and use of new sales outlets also are causing changes in traditional industry organization and in company-agent relationships.

Manpower Trends and Adjustments

Insurance carrier employment will continue to grow slowly in the next 5 years. Between 1958 and 1964, insurance carrier (SIC 63 only) employment increased at an average rate of 1.6 percent a year. Office workers, who represent about three-fourths of all insurance employees, may grow at a slower rate because the number of employees in clerical occupations probably will not increase at all. The number of sales agents (reported in SIC 63), however, is expected to continue growing, increasing insurance carrier employment by a little over 10 percent by 1975.

	Average annual percent change
All employees	
1958–64	1.6

Entry clerical jobs for girls will not be as numerous as formerly. As home offices consolidate more operations within their EDP systems, and field office recordkeeping is eliminated, entry clerical jobs will be reduced. Although the high rate of turnover among young clerks will continue to provide some openings, job opportunities for female high school graduates probably will decrease, especially in cities such as Des Moines, Omaha, Hartford, Jacksonville, Portland (Maine), and Springfield (Illinois), where insurance offices employ a significant proportion of the clerical labor force.

EDP programing, systems analysis, and operating jobs will continue to increase. It is estimated that about 19,000 people were working in EDP units in 1963. About 8,000 of these employees were in occupations which did not exist in 1950. Slightly over a fifth of the workers in EDP units were in planning and programing occupations, and about 15 percent were in computer console or related equipment operation. Almost two-fifths of the EDP workers, however, were engaged in keypunching jobs —the same type of work required in older electric accounting machine units. Over a fifth of the EDP staff were engaged in supporting clerical work. They included computer tape librarians, coding clerks, and receptionist-secretaries.

Fifty-five percent of the companies already using computers reported, in the BLS survey, that they expected the EDP jobs to increase in their companies by 1966; nearly all of the others expected no change. The reasons given for expecting growth in EDP staff were plans for additional applications—or for development of sophisticated "real time" systems—and expected company growth. Subsequent discussions with industry experts indicated that the trends as seen in 1963 are still valid for the 1966–70 period.

Keypunch operator jobs probably will not increase between 1965 and 1970. Automatic input techniques (such as optical scanning), increased use of "turn-around" documents, consolidation of records and separate processing units, and the completion of EDP conversions by more recently automated companies will result in a decline in the growth rate of keypunch operator jobs. Among the surveyed companies that had plans to install optical scanners, for example, those that employed 40 percent of the keypunch operators expected this group to decline in size. A number of these companies based their predictions on their optical scanning plans. Among companies without plans for optical scanning, those employing nearly 55 percent of the keypunch operators expected this group to increase.

Tabulating machine operator jobs will decline rapidly. About 70 percent of the surveyed companies that operated computers reported that EDP had caused a decline in the number of tabulating machine, or electric accounting machine, operators. Most of these employees are men. Companies employing nearly 80 percent of the 4,400 tabulating machine operators still employed in 1963 expected a further decline by 1966. These card tabulating departments, which have existed in some insurance companies for many decades, will soon be virtually eliminated from the industry.

Companies generally utilize attrition rather than layoffs to reduce employment. Attrition and transfer, often with retraining, usually has been sufficient to adjust the occupational structure to new EDP requirements. Industry growth and relatively high turnover among young women clerks provided sufficient openings to absorb EDP-affected employees. Information from case studies indicates that during the first year or two after EDP has been scheduled for installation, records conversion often requires additional staff in clerical, supervisory, and technical occupations. However, since most insurance companies have already passed through these initial adjustment stages, future adjustment of the clerical work force to reductions caused by increasingly consolidated systems may be more difficult. Elimination of recordkeeping from field offices may cause particular problems for clerical workers, even if transfers can be offered.

Most employees in EDP occupations in 1963 had been recruited from other jobs within the company. Slightly over 70 percent of the EDP staff had been recruited from other areas of the company, according to the BLS survey. Reliance on the company's own personnel as a source for EDP trainees was particularly marked in filling positions for systems analyst, EDP supervisor, computer console and peripheral equipment operators, and supporting clerical jobs. Maintenance of EDP equipment was almost always contracted out to the equipment manufacturer.

About 60 percent of all EDP unit workers were women. Most women EDP employees (about 90 percent) were engaged in keypunch and supporting clerical jobs such as those of tape librarians, data typists, and coding, scheduling, card, or tape file clerks. They constituted about 93 percent of all employees in these occupational groups in 1963. Women comprised only 15 percent of the relatively highly skilled systems analysts and programers. There were also few women among console and peripheral-equipment operators, and EDP supervisory staff.

Shiftwork was found frequently among companies with EDP. About 55 percent of the companies in the BLS survey had evening or night shift operators in EDP units. Relatively few of these companies, however, had other office units on shiftwork. In most cases, the fully operating EDP unit may be run by a console operator, and possibly one or two peripheral equipment operators. Large batches of work, such as a premium billing run, may be scheduled regularly for night shifts. Some companies indicated that special night crews of keypunch operators were recruited for particularly heavy jobs of records conversion, especially during the period immediately prior to the first EDP installation. When computers are used in real time network systems, shift operations may be almost universal in the insurance industry, although only a small staff in the home office would be required to run the central computer; field transmission would be automatic.

Selected References

Technological Developments

"Instant Information," *Best's Insurance News*, Life Edition, July 1965, pp. 27, 38.

Jones, W. Everett. "The Effects of Electronics," *Best's Insurance News*, Life Edition, July 1962, pp. 67–70.

Kornblum, Richard D. "Insuring Profitable Policies," *Business Automation*, June 1965, pp. 55–59, 70–72.

Life Office Management Association, *EDP in Life Insurance*, Proceedings of Automation Forum (New York, Life Office Management Association, 1962).

Life Office Management Association, *Toward Total Systems for Total Service*, Proceedings of Automation Forum (New York, Life Office Management Association) 1965.

Life Office Management Association, Automation Report No. 10, *EDP Applications in Life Insurance Companies* (New York, Life Office Management Association, 1965).

McLaughlin, J. G. "Optical Scanning," *Best's Insurance News*, Life Edition, December 1962, pp. 31, 42, 44.

Reading Machines for Data Processing; Their Prospective Employment Effects, Manpower Report No. 7, Office of Manpower, Automation, and Training, U.S. Department of Labor, 1963.

Manpower Trends and Outlook

Adjustments to the Introduction of Office Automation (BLS Bulletin 1276, 1960).

A Large Life Insurance Company Automates, Automation Program Report No. 3, Bureau of Employment Security, U.S. Department of Labor, 1964.

Impact of Office Automation in the Insurance Industry (BLS Bulletin 1468, 1965).

Industry Wage Survey, Life Insurance, May–July 1961 (BLS Bulletin 1324, 1962).

The Federal Government (SIC 91)

Summary of Outlook Through 1970

More widespread and intensive use of computers, electronic reading equipment, quick copy devices, materials handling systems, and data transmission and communications networks is expected during the years ahead. Further significant gains in efficiency are likely, particularly in routine clerical and in materials handling functions.

Employment in the Federal government is expected to increase but at a relatively low annual rate. Some clerical jobs will be cut back. But systems analysts, programers, and computer operators will increase. Through manpower planning and training programs, federal agencies are seeking to minimize displacement due to technological changes. Some experts expect relocation of employees to be a major problem.

Outlook for Technology

Electronic data-processing in government is growing rapidly. First used by the Bureau of the Census in 1951, an estimated 2,188 electronic computers were in operation throughout the Government by mid-1965 (exclusive of some military and classified operations). Computer operations are being applied to a wide variety of routine clerical tasks including accounting, check disbursing, insurance payments, tax return processing, and inventory control. Computers are also being applied to a large number of important scientific and engineering areas, such as meteorology, missile and satellite tracking and control, medicine, design and structural engineering, and nuclear research.

More than 14,000 employees work as administrators, analysts, programers, and operators on digital computer systems. This figure does not include thousands who are working in these positions, but are not so classified, and military personnel. In addition, thousands of keypunch operators and clerical personnel are engaged in EDP supporting tasks.

The outlook for 1970 is for substantial increases in computer use. A Budget Bureau survey indicates that 2,451 computers may be installed in government agencies by mid-1966—a gain of 85 percent over the number (1,326) of computers installed by mid-1963. The impact on employment will increase further as usage is extended within the agencies having computers. Arrangements for government agencies to share computers have been completed in 13 major cities including New York, Washington, Chicago, and Los Angeles, and will be gradually extended to agencies in other metropolitan areas.

Electronic computers and related equipment have made possible significant gains in productivity. For example, the Bureau of the Census in 1961 performed—with fewer employees—more than twice the volume of work handled in 1952. It is widely recognized that thousands of additional employees would be needed to produce the work now processed by electronic computers.

Optical scanning devices may be in widespread use by the early 1970's. Agencies are exploring the potential of optical character recognition (OCR) equipment for automatically reading printed and handwritten documents. Optical scanning can extend the capability of electronic data-processing by eliminating manual transcription and speeding the input of data to computers. As the equipment scans and "reads" documents, the characters are transcribed automatically onto card or paper tape, or fed directly into computers. According to the Civil Service Commission (CSC), employment of keypunch operators may be cut back by 50 to 90 percent, where adopted.

Communications systems are being extended and improved. The Federal Telecommunications System (FTS), expanded in February 1963, now involves a network of leased long-distance circuits interconnecting Federal civilian offices in 406 metropolitan areas. Nearly all government agencies are or will soon be included in the system which provides equipment capability for telephone, teletypewriter, data transmission, facsimile, and other communications mediums.

By using FTS facilities, charges for telephone service are significantly below comparable commerical rates, service is improved, and the average number of telephones served per operator is higher. A program is also underway to consolidate switchboard facilities and to install Centrex (automated) telephone equipment. In one recent consolidation, 54 PBX stations were eliminated, resulting in a cut-back of more than 80 operator positions.

Mechanization of Post Office operations is underway to handle the growing workload. Nearly 70 billion pieces of mail were handled by the Post Office Department in 1964; the volume is projected to reach 90 billion pieces by 1970 and 125 billion by 1980. Employment—585,000 in 1964—is also expected to increase, but at a lower rate than output. Mail processed per man-year may rise by 21 percent between 1960 and 1980.

Mechanization of mail handling and sorting —operations involving 30 percent of the work force in a typical post office—is being studied. One goal is to reduce by 50 percent the number of times that first class mail is handled.

Research is underway to improve letter sorting machines by incorporating electronic memory equipment and optical scanning devices. This would eliminate manual keyboards on letter sorters, along with human reading in sorting about 80 percent of all letter mail. In 1963, 69 sorting machines were installed in six large post offices. The potential is estimated at 39–67 additional post offices which will require between 188–388 more letter sorting machines. Specialized numeric readers are under development for use with the new 5-digit "ZIP" code.

Improved parcel post and sacked mail sorting machines are being used more extensively in larger post offices. One automated parcel-post system in a Miami, Fla., post office can handle 6,000 packages an hour—double the capacity of the former manual system. Mechanical facing-canceling machines, which require six operators, are replacing manual procedures and old style equipment, which required 10 men. Magnetically controlled conveyor systems for transporting and sorting mail trays and patron self-service devices are also undergoing field tests.

Mechanization may be stepped up under a post office program to transfer mail workloads from small post offices (which cannot support extensive mechanization) to large volume post offices.

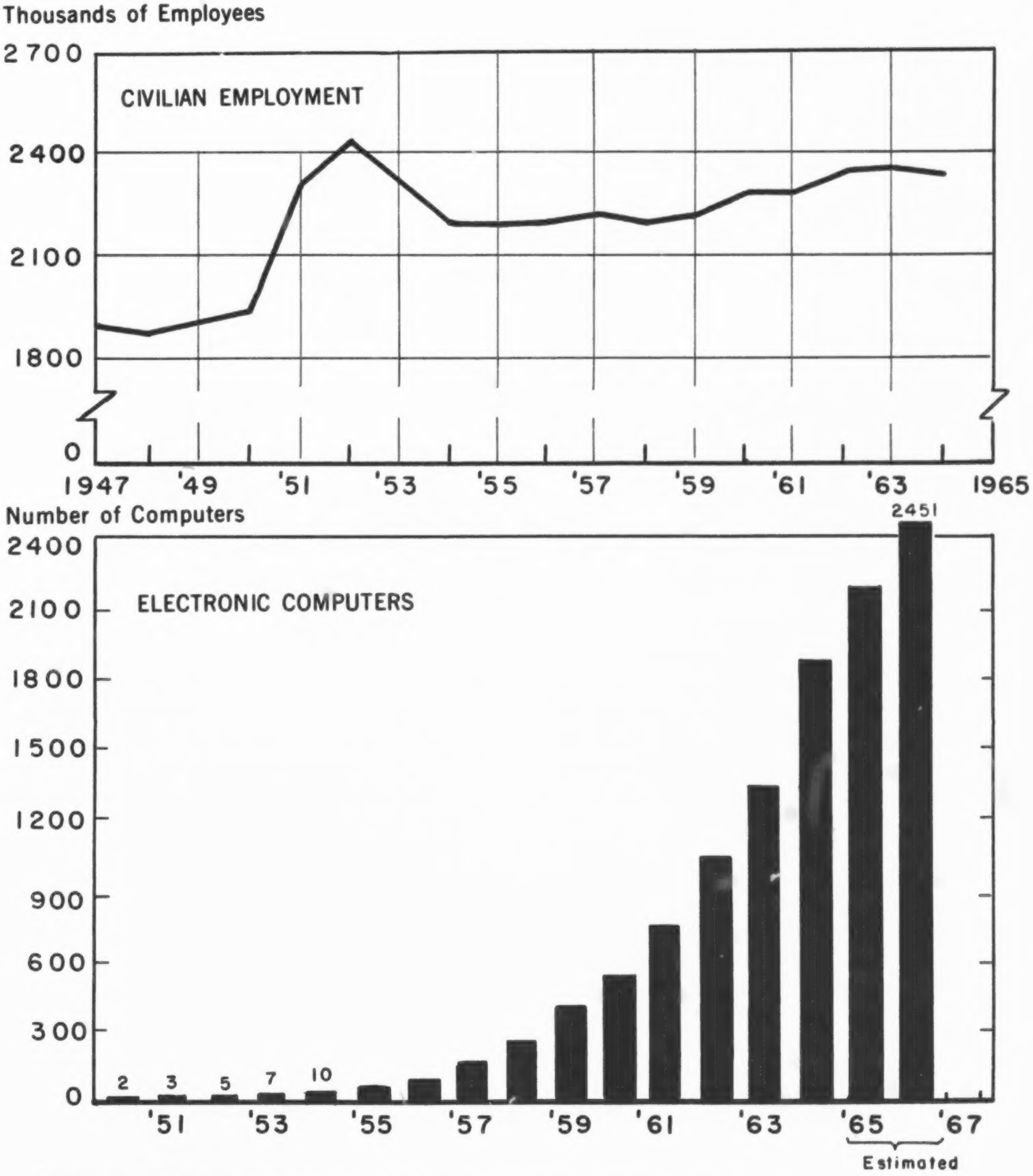
Automation of materials handling is underway in warehouse and supply operations. In the General Services Administration's (GSA) major supply depots, an integrated order processing and materials handling system is in operation for supply distribution, from the receipt of an order, to selection, packing, shipping, and billing. Computers, located in each GSA Regional Office, automatically prepare nearly all bills of lading and often provide automatic shipment consolidation and routing. Modern conveyor systems used in GSA warehouses move goods with minimum manual handling. In the Department of Defense, automated materials handling equipment and electronic computers are also achieving significant laborsavings in supply operations.

Manpower Trends and Outlook

Output per man-hour in key Government operations is increasing. A recent Budget Bureau report cites examples of significant productivity gains over the past decade in several agencies which installed electronic computers and other advances in technology. For example, in the Veterans Administration's Department of Insurance, output per man-hour increased at an average annual rate of 9.8 percent between 1955 and 1962. In a division of the Treasury Department, the output of checks and bonds issued per man-year more than tripled between 1949 and 1962.

Employment is expected to continue to rise but only moderately. According to CSC projections, total Federal Government employment may rise by 68,000 workers between mid-1964 and mid-1968, an average annual growth rate below 1 percent. Total employment in the Federal Government was 2,348,000 in 1964, compared with 2,217,000 in 1957, and 1,892,000 in 1947. Be-

EMPLOYMENT AND NUMBER OF COMPUTERS IN THE FEDERAL GOVERNMENT



Sources: Employment, Civil Service Commission; computers, Bureau of the Budget.

	Average annual percent change
Civilian employment, all employees	
1947–57	1.6
1957–64	.8

tween 1957 and 1964, employment grew at an average annual rate of only 0.8 percent, 50 percent below the annual growth rate of 1.6 percent between 1947–57.

Routine clerical jobs, including keypunch-operator positions, are expected to decrease significantly in number as optical scanners and other advances in automation equipment become more prevalent. Accounting and statistical clerical occupations, for example, may decline by 14 percent between mid-1963 and mid-1968, according to the Civil Service Commission. Blue-collar employment is also projected to decline significantly over the next few years.

Professional and technical workers are expected to increase significantly. According to CSC projections, this occupational group may increase by 17 percent between 1964 and 1968, as technical and scientific programs are expanded. Mathematicians, mathematical statisticians, educators, physical scientists, and engineers are occupations expected to show the greatest growth rates.

Recruiting employees experienced in electronic computer operations could be a major problem. By 1968, the CSC estimates that the number of employees in EDP positions may be 50 percent greater than in 1963, as agencies extend computer operations. Systems analysts and programers may be in especially short supply. Middle managers and executives will need to acquire additional skills and techniques to keep pace with changing computer technology. Training programs will become increasingly important as computer applications become more complex and experienced employees more difficult to locate.

Federal agencies have tried to minimize displacement through manpower planning. Separations and reassignments due to automation were minimal over a 3-year span in 16 agencies surveyed by the CSC in 1963–64. In the conversion to electronic data-processing in the Internal Revenue Service, attrition, advance notice, transfer, and retraining helped avoid layoffs. Special Civil Service Commission actions including waiver of job qualification standards during reassignments for some employees displaced by EDP have also been helpful in the IRS and other agencies. Growth in agency programs and new positions created by automation have also facilitated reassignment of displaced employees. In the Post Office Department, the policy has been to mechanize gradually so that manpower adjustments could be facilitated through normal attrition and regulation of hiring. Full-time career employees reportedly would not be laid off.

Relocation of displaced employees may be the foremost task facing Federal administrators. The closing down of obsolete facilities in the Department of Defense and other agencies may involve transfer of thousands of employees to jobs in new locations. In the IRS conversion to computers, employees were found to be reluctant to sever community ties and undertake the financial losses often associated with moving. Some experts recommend complete reimbursement of moving expenses to encourage mobility, and a coordinated effort by agencies to find jobs elsewhere within the community for workers who cannot relocate.

Reassignment and retraining may become more difficult as automation eliminates routine jobs to which displaced employees had been reassigned in the past. Expansion of automation may pose challenging problems for blue-collar workers because their skills may not be as adaptable to other occupations as are the skills of white-collar workers. Older employees and supervisors displaced by automation may also need special attention, including retraining.

Rapid technological change is reportedly causing skill obsolescence, downgrading, and job displacement among civilian mechanics and electricians. Thousands of jobs in defense installations have been made obsolete as weapon systems have become highly complex. Training programs have been successful in preparing displaced blue-collar employees for electronic technician jobs and other positions. However, some employees reportedly have experienced difficulty in adjusting to training and new duties.

Special Federal Government and union groups are exploring the manpower implications of automation. The CSC's Interagency Advisory Group's Committee on Automation and Manpower currently has several "Task Forces" investigating such topics as personnel adjustments required by automation; techniques for projecting and reporting manpower requirements; manning and utilization of electronic computers; and prospects for future technological innovations. A special committee of the AFL–CIO Government Employes Council, representing 31 Federal and postal employee unions, has also been established recently to study and report the effects of changing technology on Federal workers.

Selected References

U.S. Bureau of the Budget, Executive Office of the President, *Inventory of Automatic Data Processing Equipment in the Federal Government.* (1965), 365 pp.

U.S. Bureau of the Budget, Executive Office of the President, *Measuring Productivity of Federal Government Organizations.* (1964), 370 pp.

U.S. Bureau of the Budget, Executive Office of the President, *War on Waste.* (1965), 90 pp.

U.S. Civil Service Commission. *Federal Workforce Outlook, Fiscal Years 1965–1968.* (November 1964), 52 pp.

U.S. Congress, House of Representatives, Committee on Post Office and Civil Service. *A Study of the Impact of Automation on Federal Employees.* Prepared by the United States Civil Service Commission. 88th Cong., 2d sess. (August 1964), 52 pp.

U.S. Congress, House of Representatives, Committee on Post Office and Civil Service. *Use of Electronic Data Processing Equipment in the Federal Government.* (October 1963), 121 pp.

U.S. Department of Labor, Bureau of Labor Statistics. *Impact of Office Automation in the Internal Revenue Service,* (BLS Bulletin 1364, 1963), 108 pp.

U.S. General Services Administration. *Annual Reports of the Administrator of General Services—Fiscal Years 1963 and 1964.* (1964 and 1965).

U.S. Post Office Department. *Annual Reports of the Postmaster General—1963 and 1964.* (1964 and 1965.)

U.S. Post Office Department. *Research, Development, and Mechanization in the U.S. Post Office Department.* An Interim Report to the Postmaster General by the Post Office Department Advisory Board. (February 1963), 65 pp.

PART V. SELECTED BIBLIOGRAPHY

Technological Change and Forecasts

Ad Hoc Committee on the Triple Revolution. *The Triple Revolution; An Appraisal of the Major U.S. Crises and Proposals for Action*, Washington, Maurer, Fleisher, Zon and Associates, 1964. 29 pp.

The Age of Electronics, Edited by Carl F. J. Overhage, New York, McGraw-Hill Book Co., 1962. 218 pp.

American Assembly, Columbia University. *Automation and Technological Change.* Edited by John T. Dunlop, Englewood Cliffs, N.J., Prentice-Hall, 1962. 184 pp.

Aronson, Robert A. "Perspective on Automation," *ILR Research*, No. 3, 1965, pp. 3–11.

Automation: A Discussion of Research Methods, Labour and Automation, Bulletin No. 1, International Labour Office, Geneva, 1964. 276 pp.

Automation and Technological Changes, Proceedings of the Battelle-American Assembly, May 9–11, 1963, Battelle Memorial Institute, July 1963. 32 pp. (Papers by James R. Bright and Donald N. Michael.)

Automation-Implications for the Future. Edited by M. Phillipson, New York, Vintage Books, 1962. 456 pp.

Barach, Arnold and the Kiplinger Washington Editors. *1975 and the Changes to Come*, New York, Harper & Brothers, 1962. 195 pp.

Basic Research and National Goals, A report to the committee on Science and Astronautics, U.S. House of Representatives, by the National Academy of Sciences, Washington, 1965. 336 pp.

Bell, Daniel. "The Study of the Future," *The Public Interest*, Fall 1965, pp. 119–130.

Berkeley, Edmund C. *The Computer Revolution*, New York, Doubleday and Co., Inc., 1962. 249 pp.

Bright, James R. *Automation and Management*, Boston, Graduate School of Business Administration, Harvard University, 1958. 270 pp.

——. "Opportunity and Threat in Technological Change," *Harvard Business Review*, November/December 1963, pp. 76–86.

——. *Research, Development and Technological Innovation; An Introduction*, Homewood, Ill., Richard D. Irwin, 1964. 783 pp.

——. Editor. *Technological Planning on the Corporate Level*, Cambridge, Mass., Harvard Graduate School of Business Administration, 1962. 253 pp.

Brozen, Yale. *Automation: The Impact of Technological Change*, American Enterprise Institute for Public Policy Research, March 1963. 47 pp.

Buckingham, Walter. *Automation: Its Impact on Business and People*, New York, Harper & Brothers, 1961. 196 pp.

Burck, Gilbert. *The Computer Age*, New York, Harper & Row, 1964. 148 pp.

Charyk, Joseph V. "The Role of Satellites in World Communications," *Proceedings of Fifty-First National Foreign Trade Convention*, 1964, pp. 86–98.

Clague, Ewan. *Measurement of Technological Change*, Paper for Conference on Employment Problems of Automation and Advanced Technology, International Institute for Labour Studies, Geneva, Switzerland, July 20–24, 1964, Washington, U.S. Department of Labor, Bureau of Labor Statistics, 1964. 13 pp.

Clarke, Arthur C. *Profiles of the Future*, New York, Bantam Books, Inc., 1964. 235 pp.

Colm, Gerhard. *America, 1980: Man's Work and Who will do it in 1980*, Lecture at Graduate School of U.S. Department of Agriculture, March 9, 1965, Washington, National Planning Association, 1965, 19 pp.

Concentration, Invention, and Innovation, Hearings Before the Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary, U.S. Senate, 89th Cong., 1st sess., 1965, pp. 1073–1534.

Convertibility of Space and Defense Resources to Civilian Needs: A Search for New Employment Potentials, Subcommittee on Employment and Manpower, Committee on Labor and Public Welfare, U.S. Senate, Washington, 1964. 518 pp.

Diebold, John. *Beyond Automation: Managerial Problems of an Exploding Technology*, New York, McGraw-Hill Book Co., 1964. 220 pp.

——. "What's Ahead in Information Technology," *Harvard Business Review*, September/October 1965, pp. 76–82.

Economics of R&D, Edited by Richard Tybout, Columbus, Ohio, Ohio State University Press, 1965.

Fabricant, Solomon. *Measurement of Technological Change*, Seminar on Manpower Policy and Program, Manpower Administration, U.S. Department of Labor, Washington, July, 1965. 32 pp.

Goals for Americans, The American Assembly, Englewood Cliffs, N.J., Prentice Hall, Inc., 1960. 372 pp. (Chapters by Clark Kerr, Herbert Stein, Edward F. Denison and Thomas J. Watson, Jr.)

Gordon, Theodore J. *The Future*, New York, St. Martin's Press, 1965. 184 pp.

——. and Olaf Helmer. *Report on a Long Range Forecasting Study*, Santa Monica, Calif., The Rand Corporation, 1964.

Greenberg, Leon and Edgar Weinberg. "Nation-wide Studies in the United States, *Labour and Automation*, Bulletin No. 1, International Labour Office, 1964, pp. 141–164.

Hearings Before the Commission on Manpower, Automation, and Technology, State of California, November 19 and 20, 1964, San Francisco, Calif., 1965. 145 pp.

Hirt, Francis L. "New Light on Patterns of Output Growth," *Survey of Current Business*, September 1961, pp. 13–17.

The Impact of Science on Technology, Aaron W. Warner, Dean Morse and Alfred S. Eichner, Editors, New York, Columbia University Press, 1965. 221 pp.

Killingsworth, Charles (ed.). "Automation" (entire issue), *The Annals of the American Academy of Political and Social Science*, March 1962, 198 pp. (Papers by John Diebold, Walter Buckingham, Seymour L. Wolfbein, Malcolm L. Denise, Walter P. Reuther, and others.)

Landsberg, Hans H., Leonard L. Fischman and Joseph L. Fisher. *Resources in America's Future*, Baltimore, Md., Johns Hopkins Press, 1963. 1017 pp.

Leaver, Eric W. "The Next Fifteen Years of Automation," *Automation*, September 1962, pp. 52–58.

Lynn, Frank. "Metalworking in 1980," *American Machinist*, December 9, 1963, pp. 81–85.

Mansfield, Edwin. "The Process of Technical Change," *Battelle Technical Review*, April 1964, pp. 3–6.

McGraw-Hill Yearbooks of Science and Technology, 1963, 1964, and 1965, New York, McGraw-Hill Book Co., Inc., 1963, 1964, and 1965.

Mesthene, Emmanuel G. "On Understanding Change: The Harvard University Program on Technology and Society," *Technology and Culture*, Spring 1965, pp. 222–235.

Michael, Donald N. *Cybernation and Social Change*, Seminar on Manpower Policy and Program, Report No. 1. Washington, U.S. Department of Labor, Manpower Administration, Office of Manpower, Automation and Training, 1964. 34 pp.

——. *Cybernation: The Silent Conquest*, Santa Barbara, Calif., Center for the Study of Democratic Institutions, 1962. 48 pp.

——. *The Next Generation*, New York, Random House, 1965. 218 pp.

National Bureau of Economic Research. *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton, N.J., Princeton University Press, 1962. 635 pp.

Nelson, Richard R. "Technical Advance and Economic Growth," *Battelle Technical Review*, May 1965, pp. 9–15.

New Decision-Making Tools For Managers, Mathematical Programing as an Aid in the Solving of Business Problems, Edited by Edward C. Bursk and John F. Chapman, New York, Mentor Executive Library, 1965. 413 pp.

Novick, David. "The ABC of R & D." *Challenge*, June 1965, pp. 9–13.

Outer Space, Prospects for Man and Society. Edited by Lincoln P. Bloomfield. The American Assembly, Englewood Cliffs, N.J., Prentice-Hall, Inc., 1962. 202 pp. (Papers by Leonard S. Silk, Donald N. Michael, and others.)

Pierce, John R. "Communications Technology and the Future," *Daedalus*, Spring 1965, pp. 506–517.

Proceedings of the Institute of Radio Engineers. 50th Anniversary Issue, May 1962. 1447 pp.

"The Promise and Problems of Technological Change," *Annual Report of the Council of Economic Advisers*, Washington, U.S. Council of Economic Advisers, 1964, pp. 85–111.

"Reading Machines for Data Processing: Their Prospective Employment Effects," *Manpower Report*, No. 7, Washington, U.S. Department of Labor, Office of Manpower, Automation, and Training. 12 pp.

Reinoud, H. "Methods for Studying the Extent and Rate of New Technologies and Their Probable Effects," *Labour and Automation*, Bulletin No. 1, Geneva, International Labour Office, 1964, pp. 97–111.

Salter, W. A. *Productivity and Technical Change*, Cambridge, England, Cambridge University Press, 1960. 198 pp.

Schon, Donald A. "Innovation by Invasion," *International Science and Technology*, March 1964, pp. 52–61.

Scientific and Technical Manpower Resources, Washington, National Science Foundation, 1964. 184 pp.

Shultz, George P. and Thomas Whisler. *Management Organization and the Computer*, Glencoe, Ill., The Free Press, 1960. 257 pp.

Siegel, Irving H. "The Role of Scientific Research in Stimulating Economic Progress," *American Economic Review*, May 1960, pp. 340–345.

——. "Scientific Discovery, Invention, and the Cultural Environment," *Patent, Trademark, and Copyright Journal*, Fall 1960, pp. 233–251.

——. "Technological Change and Long-Range Forecasting," *Journal of Business*, July 1953, pp. 141–156.

Simon, Herbert A. *The Shape of Automation for Men and Management*, New York, Harper & Row, 1965. 111 pp.

Solo, Robert A. "Gearing Military R & D to Economic Growth," *Harvard Business Review*, November–December 1962, pp. 49–60.

Some New Technologies and their Promise for the Life Sciences, Washington, The Life Sciences Panel, President's Science Advisory Committee, January 1963.

5 OF 5

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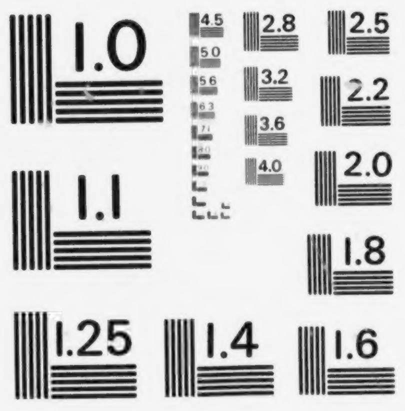

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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Stanford Research Institute, Stanford University. *Management Decisions To Automate,* Prepared for the Office of Manpower, Automation and Training, U.S. Department of Labor, 1964. (Various pagings.)

Survey of Computers and Computer Usage, New York, McGraw-Hill Book Co., Department of Economics, April 1965.

Technology and Social Change, Edited by Eli Ginzberg, New York, Columbia University Press, 1964. 158 pp.

Terborgh, George. *The Automation Hysteria,* Washington, Machinery and Allied Products Institute and Council for Technological Advancement, 1965.

Theobald, Robert. *Free Men and Free Markets,* New York, Clarkson N. Potter, Inc., 1963. 208 pp.

Thomson, Sir George. *The Foreseeable Future,* New York, The Viking Press, 1955. 216 pp.

Toward Better Utilization of Scientific and Engineering Talent, A Program for Action, National Academy of Sciences, 1964. 153 pp. (Papers by Arthur M. Ross, Richard Bolt, and others.)

Transforming and Using Space-Research Knowledge (Ten Diversified Views), NASA–UCLA Symposium and Workshop, Los Angeles, Calif., June 2, 1964, Washington, National Aeronautics and Space Administration, 1964. 110 pp.

U.S. Industrial Outlook, 1966, Washington, Business and Defense Services Administration, U.S. Department of Commerce, [illegible]cember 1965. 213 pp.

Walker, Charles R., and Adelaide G. Walker. *Modern Technology and Civilization: An Introduction to Human Problems in the Machine Age,* New York, McGraw-Hill Book Co., 1962. 469 pp.

"What Automation Means to America," *Automation,* Vol. 11, April 1964 (entire issue).

The World in 1984, Vol. 1, Edited by Nigel Calder, Baltimore, Md., Penguin Books, 1965. 215 pp.

Manpower Trends and Outlook

Alterman, Jack. "Interindustry Employment Requirements," *Monthly Labor Review,* July 1965, pp. 841–850.

Automation and the Challenge to Education, edited by Luther H. Evans and George E. Arnstein, Washington, National Education Association, 1962. 199 pp.

The Battle Against Unemployment, edited by Arthur M. Okun, New York, W. W. Norton and Co., Inc., 1965. 203 pp. (Chapters by Alvin H. Hansen, Arthur F. Burns, Paul A. Samuelson and others.)

Barkin, Solomon. "Manpower and Management in an Automated Age," *The OECD Observer,* February 1965, pp. 21–24.

Bok, Derek. *Automation, Productivity, and Manpower Problems,* Prepared for the President's Advisory Committee on Labor-Management Policy, Washington, U.S. Department of Labor. 20 pp.

Clague, Ewan. *Employment, Automation, and Economic Growth in the United States,* Washington, Bureau of Labor Statistics, 1964. 24 pp.

——. and Leon Greenberg. "Technological Change and Employment," *Monthly Labor Review,* July 1962, pp. 742–746.

Crossman, E. R. F. W. *Automation and Skill,* Problems of Progress in Industry Series, No. 9. London, Great Britain Department of Scientific and Industrial Research, 1960. 58 pp.

David, Henry. *Manpower Policies for a Democratic Society,* New York, Columbia University Press, 1965. 119 pp.

Davis, Louis E. "The Effects of Automation on Job Design," *Industrial Relations,* October 1962, pp. 53–71.

Employment of Scientific and Technical Personnel in Industry, 1962, (BLS Bulletin 1418, 1964). 86 pp.

"Employment of Unskilled Workers, *Monthly Report on the Labor Force, October 1965,* U.S. Department of Labor, 1965, pp. 6–12.

Fine, Sidney A. *The Nature of Automated Jobs and Their Educational and Training Requirements,* McLean, Va., Human Sciences Research, Inc., June 1964. 105 pp.

Formal Occupational Training of Adult Workers, Manpower/Automation Research Monograph No. 2, Washington, U.S. Department of Labor, Manpower Administration, December 1964. 48 pp.

Fulton, Joseph F. "Employment Impact of Changing Defense Programs," *Monthly Labor Review,* May 1964, pp. 508–516.

Garfinkle, Stuart H. *Job Changing and Manpower Training,* Manpower Report No. 10, Washington, U.S. Department of Labor, 1964. 8 pp.

Ginzberg, Eli. "Automation and Minority Manpower: Challenge to Management," *Advanced Management Journal,* Vol. 29, No. 2, April 1964, pp. 70–74.

——. Dale L. Heistand, and Beatrice G. Rubens. *The Pluralistic Economy,* New York, McGraw-Hill Book Co., Inc., 1965. 235 pp.

Goldstein, Harold. "BLS Occupational Trend Projections: An Appraisal," *Monthly Labor Review,* October 1963, pp. 1135–1138.

——. "Education and Worklife in a Changing Economy," *Occupational Outlook Quarterly,* September 1965, pp. 1–4.

Gordon, Margaret S. *Retraining and Labor Market Adjustment in Western Europe,* Washington, U.S. Department of Labor, Manpower Administration, 1965. 230 pp.

——. "U.S. Manpower and Employment Policy—A Review Essay," *Monthly Labor Review,* November 1964, pp. 1314–1321.

Gordon, R. A. *Has Structural Unemployment Worsened?,* Berkeley, Calif., Institute of Industrial Relations, University of California, 1964. 24 pp.

——. *Twenty Years of Economic and Industrial Change,* Washington, U.S. Department of Labor, Manpower Administration, 1965. 45 pp.

Greenberg, Leon. *The Relationship of Automation, Productivity, and Employment; Current Developments in the United States,* Washington, Bureau of Labor Statistics, June 1964. 10 pp.

——. "Statement Before the Subcommittee on Employment and Manpower," *Nation's Manpower Revolution,* Vol. 5, U.S. Senate, Committee on Labor and Public Welfare, 88th Cong., 1st sess., Sept. 26, 1963, pp. 1578–1596.

——. and Edgar Weinberg. "Technological Change, Productivity and Employment," *Occupational Outlook Quarterly,* Vol. 8, No. 3. September 1964, pp. 5–11.

Haber, W., L. Ferman, and J. Hudson. *The Impact of Technological Change,* Kalamazoo, Mich., W. E. Upjohn Institute for Employment Research, 1963. 62 pp.

Heilbroner, Robert L. "Men and Machines in Perspective," *Public Interest,* Fall 1965, pp. 27–36.

Henle, Peter. "Recent Growth of Paid Leisure for U.S. Workers," *Monthly Labor Review,* March 1962, pp. 249–257.

Holland, Susan S. "Long Term Unemployment in the 1960's," *Monthly Labor Review,* September 1965, pp. 1069–1076.

Impact of Automation on Employment, Hearings before the Subcommittee on Unemployment and the Impact of Automation. Washington, 87th Cong., 1st sess., U.S. House of Representatives, Committee on Education and Labor, Subcommittee on Unemployment and the Impact of Automation, 1961. 793 pp.

International Labour Office. *Health and Safety Aspects of Automation and Technological Change,* Washington, U.S. Department of Labor, Office of Manpower, Automation and Training, 1964. 181 pp.

Jakubauskas, Edward B. "Retraining—A Problem Created Through Equipment Replacement," *Personnel Journal,* November 1963, pp. 512–518.

Levine, Louis. "Occupational Information and Changing Jobs," *Employment Service Review,* October 1964, pp. 1–5.

Levitan, Sar A. *Federal Manpower Policies and Programs to Combat Unemployment,* Kalamazoo, Mich., W. E. Upjohn Institute for Employment Research, 1964. 41 pp.

——. *Reducing Worktime As A Means to Combat Unemployment,* Kalamazoo, Mich., W. E. Upjohn Institute for Employment Research, 1964. 28 pp.

Liebhafsky, E. D. "Improving the Operation of Labor Markets Through Employment Service Advance Notice Systems," *Southern Economic Journal,* April 1963, pp. 317–325.

Lipstreu, Otis. "Problem Areas in Training For Automated Work," *Training Directors Journal,* November 1964, pp. 12–15.

——. "Training Implications of Automation," *Journal of the American Society of Training Directors,* June 1960, pp. 48–51.

Long Term Manpower Projections (Proceedings of a Conference Conducted by the Research Program on Unemployment and the American Economy, University of California, June 25–26, 1964), edited by R. A. Gordon, Berkeley, University of California, Institute of Industrial Relations, 1965. 64 pp.

Manpower Implications of Automation, papers by Leon Greenberg, Seymour L. Wolfbein, Ewan Clague, Louis Levine, Robert C. Goodwin, and John P. Walsh, Washington, U.S. Department of Labor, Manpower Administration, 1965. 86 pp.

Manpower Report of the President and a Report on Manpower Requirements, Resources, Utilization, and Training, Washington, U.S. Department of Labor, March 1965. 276 pp.

The Manpower Revolution, Its Policy Consequences. Excerpts from Senate Hearings Before the Clark Committee, Garth Mangum, editor, Garden City, N.J., Doubleday and Co., Inc., 1965.

Manor, Stella P. "Geographic Changes in U.S. Employment from 1950 to 1960," *Monthly Labor Review,* January 1963, pp. 1–10.

Men Without Work, The Economics of Unemployment, edited by Stanley Lebergott, Englewood Cliffs, N.J., Prentice-Hall, 1964. 183 pp.

Michael, Donald N. *Cybernation and Social Change,* Seminar on Manpower Policy and Social Change, Washington, U.S. Department of Labor, Manpower Administration, 1964. 34 pp.

National Manpower Council. *Government and Manpower: A Statement by the National Manpower Council with Background Chapters by the Council Staff,* New York, Columbia University Press, 1964. 470 pp.

National Office Management Association. "Impact of Automation on the Training of Present and Future Office Employees," *Proceedings, NOMA Problem-Solving Seminar,* Willow Grove, Pa., June 1962. 68 pp.

Occupational Outlook Handbook, 1966–67 Edition, Washington, (BLS Bulletin 1450, 1965). 858 pp.

Organisation for Economic Co-operation and Development. *Manpower Policy and Programmes in the United States*, New York, McGraw-Hill Book Co., 1964.

Ruttenberg, Stanley H. *Manpower Needs of the Future*, Report presented to American Vocational Association Convention, December 1965, Washington, U.S. Department of Labor, Manpower Administration. 52 pp.

Rutzick, Max, and Sol Swerdloff. "The Occupational Structure of U.S. Employment, 1940–60," *Monthly Labor Review*, November 1962, pp. 1209–1213.

Salner, Edward. "The Manpower Problems of Automation," *Employment Service Review*, October 1965, pp. 48, 51–54.

Scientists, Engineers, and Technicians in the 1960's; Requirements and Supply, Washington, Bureau of Labor Statistics, 1964. 68 pp.

Scott, W. H. *Office Automation, Administrative and Human Problems*, Paris, Organisation for Economic Co-operation and Development, 1965. 103 pp.

Selected Readings in Employment and Manpower, 6 Vols., Washington, 88th Cong., 2nd sess., U.S. Senate Committee on Labor and Public Welfare, Subcommittee on Employment and Manpower, 1964–65.

Shultz, George P. "Unemployment and Labor Market Policy," *Monthly Labor Review*, July 1963, pp. 808–810.

Silberman, Charles. "Technology and the Labor Market, I and II," *Fortune*, January–February 1965.

Solow, Robert M. "Technology and Unemployment," *The Public Interest*, Fall 1965, pp. 17–26.

Toward Full Employment: Proposals for a Comprehensive Employment and Manpower Policy in the United States, U.S. Senate, Committee on Labor and Public Welfare, Subcommittee on Employment and Manpower, 88th Cong., 1st sess., Washington, 1964. 148 pp.

Unemployment and the American Economy, edited by Arthur M. Ross, New York, John Wiley and Sons, 1964. 216 pp.

U.S. Department of Labor, Bureau of Apprenticeship and Training. *Training of Workers in American Industry*, Research Division Report No. 1, Washington, 1964. 16 pp.

Weber, Arnold R. "Automation and Retraining," *Proceedings, New York University Conference on Labor*, 1963, pp. 59–80.

——. "The Rich and the Poor: Employment in an Age of Automation," *Social Service Review*, Vol. 37, September 1963, pp. 249–262.

Wilcock, Richard C. and Walter H. Franke. *Unwanted Workers*, New York, Free Press of Glencoe, 1963. 340 pp.

Wolfbein, Seymour L. "Labor Trends, Manpower and Automation," *Man in A World of Work*, edited by Henry Borow, Boston, Houghton Mifflin Co., 1964, pp. 155–173.

——. "The Outlook for the Skilled Worker in the United States: Implications for Guidance and Counseling," *Personnel and Guidance Journal*, December 1961, pp. 334–339.

Adjustments to Technological Change

Aaron, Benjamin. "Reflections on the Legal Nature and Enforceability of Seniority Rights," *Harvard Law Review*, June 1962, pp. 1532–1564.

"Adaption to Technological Change Under Collective Bargaining," *Proceedings of the Twelfth Annual Labor-Management Conference*, April 12–13, 1962, pp. 1–15.

Adjusting to Technological Change, edited by Gerald G. Somers, Edward L. Cushman, and Nat Weinberg, New York, Harper and Row, 1963. 230 pp.

Backman, Jules. "Cushioning the Impact of Technological Change," *Labor Law Journal,* September 1962, pp. 731–746.

Bloch, Joseph W. "Problems of Collective Bargaining in a Changing Technology—Its Impact on Wages, Working Conditions and Fringes," *British Columbia Labour Management Conference, 1963.*

Bok, Derek and Max D. Kossoris. *Methods of Adjusting to Automation and Technological Change,* prepared for the President's Committee on Labor-Management Policy. Washington, U.S. Department of Labor. 33 pp.

Creative Collective Bargaining: Meeting Today's Challenges to Labor-Management Relations. Edited by James J. Healy, Englewood Cliffs, N.J., Prentice Hall, Inc., 1965.

Employer Attitudes Toward Advance Notice of Technological Change. Washington, U.S. Department of Labor, Bureau of Employment Security, June 1962. 41 pp.

Farwell, Donald F. *Extended Vacations; An Innovation in Collective Bargaining,* Washington, Bureau of National Affairs, Inc., 1964. 153 pp.

Freidricks, Gunter. "Planning Social Adjustment to Technological Change at the Level of the Undertaking," *International Labour Review,* August 1965, pp. 91–105.

Frye, Jack. "Attrition in Job Elimination," *Labor Law Journal,* September 1963, pp. 809–817.

Ginsburg, Barry M. "The Impact of Automation on Wage and Salary Administration," *ILR Research,* Nov. 1, 1963, pp. 3–9.

Gitlow, Abraham L. "A Note On: Technological Change, Trade Union Structure and the Appropriate Bargaining Unit," *Challenge,* October 1964, pp. 28–29.

Gray, Arlen. "Problems of Adjustment in the Automated Office," *Personnel,* July–August 1964, pp. 43–48.

Helfgott, Roy B. "Easing the Impact of Technological Change on Employees: A Conspectus of United States Experience," *International Labour Review,* June 1965, pp. 28–37.

——. and R. Beaumont. *Management, Automation and People,* New York, Industrial Relations Counselors, 1963. 378 pp.

Hildebrand, George H. "The Use of Tripartite Bodies to Supplement Collective Bargaining," *Labor Law Journal,* July 1961, pp. 655–664.

Hoos, Ida R. "The Personnel Administrator and Technological Change," *Public Personnel Review,* July 1963, pp. 152–157.

"Humanizing Technological Change," *American Federationist,* August 1964, pp. 11–16.

Kennedy, Thomas. *Automation Funds and Displaced Workers,* Boston, Harvard University Press, 1962. 374 pp.

Killingsworth, Charles C. "Collective-Bargaining Approaches to Employee Displacement Problems (Outside the Railroad Industry)," *Report of the Presidential Railroad Commission, Appendix Volume IV, Studies Relating to Collective Bargaining Agreements and Practices Outside the Railroad Industry,* Washington, 1962, pp. 194–228.

Kirsh, B. S. *Automation and Collective Bargaining,* New York, Central Book Company, 1964. 219 pp.

Kossoris, Max. "Early Retirement," *Industrial Relations,* May 1965, pp. 1–28.

Kuhn, James and Ivar Berg. "Bargaining and Work-Rule Disputes," *Social Research,* Winter 1964, pp. 466–481.

Labor Mobility and Private Pension Plans: Study of Vesting, Early Retirement and Portability Provisions, Washington (BLS Bulletin 1407, 1964), 74 pp.

Lipstreu, Otis and Kenneth A. Reed. "A New Look at the Organizational Implications of Automation," *Academy of Management Journal,* March 1965, pp. 24–31.

Major Collective Bargaining Agreements, Severance Pay and Layoff Benefit Plans, Washington (BLS Bulletin 1425–2, March 1965), 109 pp.

Major Collective Bargaining Agreements, Supplemental Unemployment Benefit Plans and Wage-Employment Guarantees, Washington. (BLS Bulletin 1425–3, June 1965). 107 pp.

McLaughlin, Richard P. "Collective Bargaining—The New Trend," *Labor Law Journal,* August 1964, pp. 499–518.

Oswald, Rudolph. "Easing Job Changes By Advance Notice," *AFL–CIO American Federationist,* December, 1965, pp. 13–17.

President's Advisory Committee on Labor-Management Policy. *Seminars on Private Adjustments to Automation and Technological Change,* Washington, May–June 1964, various paging.

——. *The Benefits and Problems Incident to Automation and Other Technological Advances,* Washington, 1962. 11 pp.

"Protecting Job Rights Through Attrition Clauses," *AFL–CIO American Federationist,* June 1965 (reprint 5 pp.).

Recent Collective Bargaining and Technological Change, Washington, Bureau of Labor Statistics, Report 266, March 1964. 14 pp.

Segal, Martin E. "Pension Plans Limitations In Solving Job Problems," *The Commercial and Financial Chronicle,* Jan. 7, 1965, p. 164.

Seligman, Ben B. "Men, Work, and the Automated Feast," *Commentary,* July 1962, pp. 9–19.

Shils, Edward B. *Automation and Industrial Relations,* New York, Holt, Rinehart and Winston, Inc., 1963. 360 pp.

Soffer, Benson. "Seniority Reform—One Answer to Displacement of the Older Worker," *Personnel,* March–April 1963, pp. 19–26.

Stern, James L. "Automation—End or a New Day in Unionism?", *Annals of the American Academy of Political Science,* November 1963, pp. 25–35.

Taylor, George W., William Haber, John T. Dunlop and Others, *Monthly Labor Review,* July 1965 (50th Anniversary Issue). 175 pp.

Williams, Laurence K. "The Human Side of a Systems Change," *Systems and Procedure Journal,* July/August 1964.

Wirtz, Willard W. *Labor and the Public Interest,* New York, Harper and Row, 1964. 196 pp.

"Worker Security in a Changing Economy," *Monthly Labor Review,* June 1963, entire issue.

Work Force Adjustments to Technological Change: Selected Employer Procedures, Washington, U.S. Department of Labor, Manpower Administration, Bureau of Employment Security, BES E–215, January 1963. 62 pp.

Bibliographies on Technological Change

Canadian Department of Labour. *A Selected Bibliography on the Social and Economic Implications of Electronic Data Processing,* Ottawa, Department of Labour, March 1964. 75 pp.

Counselor's Guide to Occupational and Other Manpower Information: An Annotated Bibliography of Selected Government Publications, Washington, Bureau of Labor Statistics, Bulletin 1421, January 1964. 87 pp.

Current Projects on Economic and Social Implications of Science and Technology, 1964, Washington, National Science Foundation. 180 pp.

Instructional Materials on Productivity and Automation: An Annotated Bibliography, by Omar Kussow; A descriptive list of films, by William Dunwiddie, Madison, University of Wisconsin, Center for Productivity Motivation, 1965. 14 pp.

International Labour Office. *A Review of Recent Soviet Literature on the Social Aspects of Automation and Technological Change in the U.S.S.R.*, Geneva, 1964.

——. *Social Aspects of Automation,* Geneva, 1963. 98 pp.

A Survey of Current Literature on Automation and Other Technological Changes, 1963–64, A Selected Annotated Bibliography, Washington, U.S. Department of Labor, Manpower Administration, 1966 (in press).

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